SOIL SURVEY OF

Buena Vista County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa State University Agriculture and
Home Economics Experiment Station and Cooperative Extension
Service and State of Iowa Department of Soil Conservation

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1968–71. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service, the Iowa State University Agriculture and Home Economics Experiment Station and Cooperative Extension Service, and the State of Iowa Department of Soil Conservation. It is part of the technical assistance furnished to the Buena Vista County Soil Conservation District. Funds appropriated by Buena Vista County and by the State of Iowa were used to defray part of the cost of this survey.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for farming, industry, or recreation.

Locating Soils

All the soils of Buena Vista County are shown on the detailed map at the back of this publication. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with a number shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise it is outside, and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in numerical order by map symbol and gives the capability classification and environmental planting group of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and the environmental planting groups.

Foresters and others can refer to the section "Use of the Soils for Environmental Plantings," where the soils of the county are grouped according to their suitability for trees and shrubs.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife Habitat and Recreation."

Engineers and builders can find, under "Use of the Soils for Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Buena Vista County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

Cover: View south of Storm Lake showing pattern of farmsteads and fields in the Sac-Primghar-Galva soil association. Small areas of Colo-Calco-Spillville and Clarion-Nicollet-Canisteo associations are along the right edge of the picture.

Contents

Issued June 1977

Summary of Tables

This page intentionally left blank.

SOIL SURVEY OF BUENA VISTA COUNTY, IOWA

BY JAMES E. SEAHOLM, SOIL CONSERVATION SERVICE

FIELD WORK BY KELVIN BRONNER, EDWIN CROCKER, LOREN GREINER, HARVEY HARMAN, RODNEY JENSON, ROBERT JONES, ROBERT POPE, AND JAMES SEAHOLM

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA STATE UNIVERSITY AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION AND COOPERATIVE EXTENSION SERVICE AND THE STATE OF IOWA DEPARTMENT OF SOIL CONSERVATION

BUENA VISTA COUNTY is in the northwestern part of Iowa. It is the third county south of the Iowa-Minnesota State line and the third one east of the Iowa-South Dakota State line. Figure 1 shows the location of Buena Vista County in Iowa. Storm Lake, the county seat (fig. 2), is about 110 miles northwest of Des Moines, the state capital. The county has an area of about 366,720 acres.

Most of the acreage of the county is in farms. It is used mainly for corn, soybeans, oats, hay, and pasture. Corn is the chief grain crop. Raising hogs and feeding beef cattle are the principal livestock enterprises. Most of the soils are dark colored and fertile. They formed mainly under prairie vegetation. The climate is subhumid and continental. The winters are cold, and the summers are warm. The growing season is long enough for all common crops to mature.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Buena Vista County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Clarion and Galva, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differ-

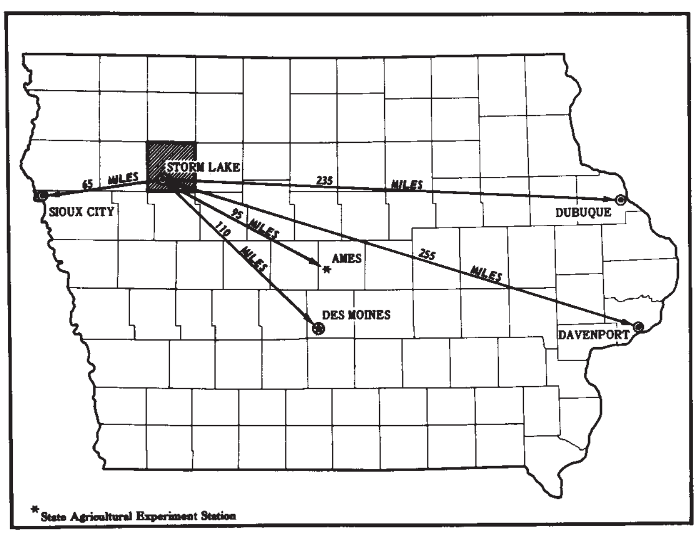


***Figure 1.*—Location of Buena Vista County in Iowa.**

***Figure 2.*—Aerial view of Storm Lake, the county seat.**

ences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Galva silty clay loam, 2 to 5 percent slopes, is one of several phases within the Galva series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. One such kind of mapping unit is shown on the soil map of Buena Vista County: the soil complex.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that it is not feasible to show them separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. The Colo-Spillville complex, 2 to 5 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Marsh is a land type in this county.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive proportional pattern of soils. It generally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful guide for broad planning of a watershed, a wooded tract, or a wildlife area or for broad planning of recreational facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning for management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils in an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The general soil map in this soil survey shows seven soil associations. Five are in the uplands, one is on benches, and one is on bottom lands. This map joins the general soil maps of Clay County and Sac County. Some of the names of the associations are different, because the relative proportion of the soils in the associations differ from county to county. The soil associations in this survey area are discussed in the following paragraphs. Textures given in the names of associations refer to the surface layer of the major soils. "Medium textured" and "moderately fine textured" in the name of association 1, for example, refer to the surface layer of Clarion, Nicollet, and Canisteo soils.

1. Clarion-Nicollet-Canisteo Association

Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to moderately sloping soils on uplands

The soils of this association are nearly level to moderately sloping loams and silty clay loams. They are on the undulating Wisconsin (Cary) till plain that has few natural streams and drainageways. This plain generally has short irregular slopes. Many knobs and hills are intermingled with areas of nearly level soils that have many landlocked depressions (fig. 3).

This association occupies about 59 percent of the county. It is about 30 percent Clarion soils, 22 percent Nicollet soils, 20 percent Canisteo soils, 14 percent Webster soils, and 14 percent minor soils (fig. 4).

Clarion soils in this association are gently sloping and moderately sloping. They generally are on irregular convex ridges and knobs on the glacial till plain. Clarion soils formed in loamy, calcareous glacial till. They are well drained.

Nicollet soils are nearly level. They generally are at intermediate elevations between the ridges of Clarion soils and the low-lying Canisteo and Webster soils. Nicollet soils generally formed in loamy glacial till. They are somewhat poorly drained.

Figure 3.—Typical area in the Clarion-Nicollet-Canisteo soil association.

Canisteo soils are nearly level. They are on low-lying flats on the glacial till plain. Canisteo soils formed in loamy, calcareous glacial sediment or glacial till. They are calcareous and poorly drained.

Webster soils are nearly level. They are on low-lying flats on the glacial till plain. Webster soils formed in loamy glacial sediment or glacial till. They are poorly drained.

The minor soils in this association are mainly in the Biscay, Blue Earth, Collinwood, Colo, Cylinder, Harps, Lanyon, Okoboji, Salida, Spillville, Storden, Talcot, Wacousta, Wadena, and Waldorf series.

The depressional, very poorly drained Blue Earth, Lanyon, and Wacousta soils occupy the shallow glacial lake basins; the depressional, very poorly drained Okoboji soils occupy the smaller landlocked depressions; and the nearly level, poorly drained Harps soils generally occupy narrow rims around the landlocked depressions and larger glacial lake basins. The nearly level, poorly drained Colo soils and the nearly level, somewhat poorly drained Spillville soils are adjacent to the drainageways and stream valleys on sloping, concave foot slopes.

Areas of fine-textured, poorly drained Waldorf soils and fine-textured, somewhat poorly drained Collinwood soils are closely intermingled with areas of Webster and Nicollet soils; areas of well-drained and somewhat poorly drained glacial outwash soils of the Wadena and Cylinder series that have sand and gravel at a depth of 24 to 40 inches are intermingled with areas of Clarion and Nicollet soils; areas of very poorly drained and poorly drained glacial outwash soils of the Talcot and Biscay series that have sand and gravel at a depth of 24 to 40 inches are intermingled with areas of Canisteo and Webster soils; and areas of moderately sloping or strongly sloping, calcareous, loamy Storden soils and moderately sloping or strongly sloping, shallow, moderately coarse textured Salida soils are intermingled with areas of Clarion soils.

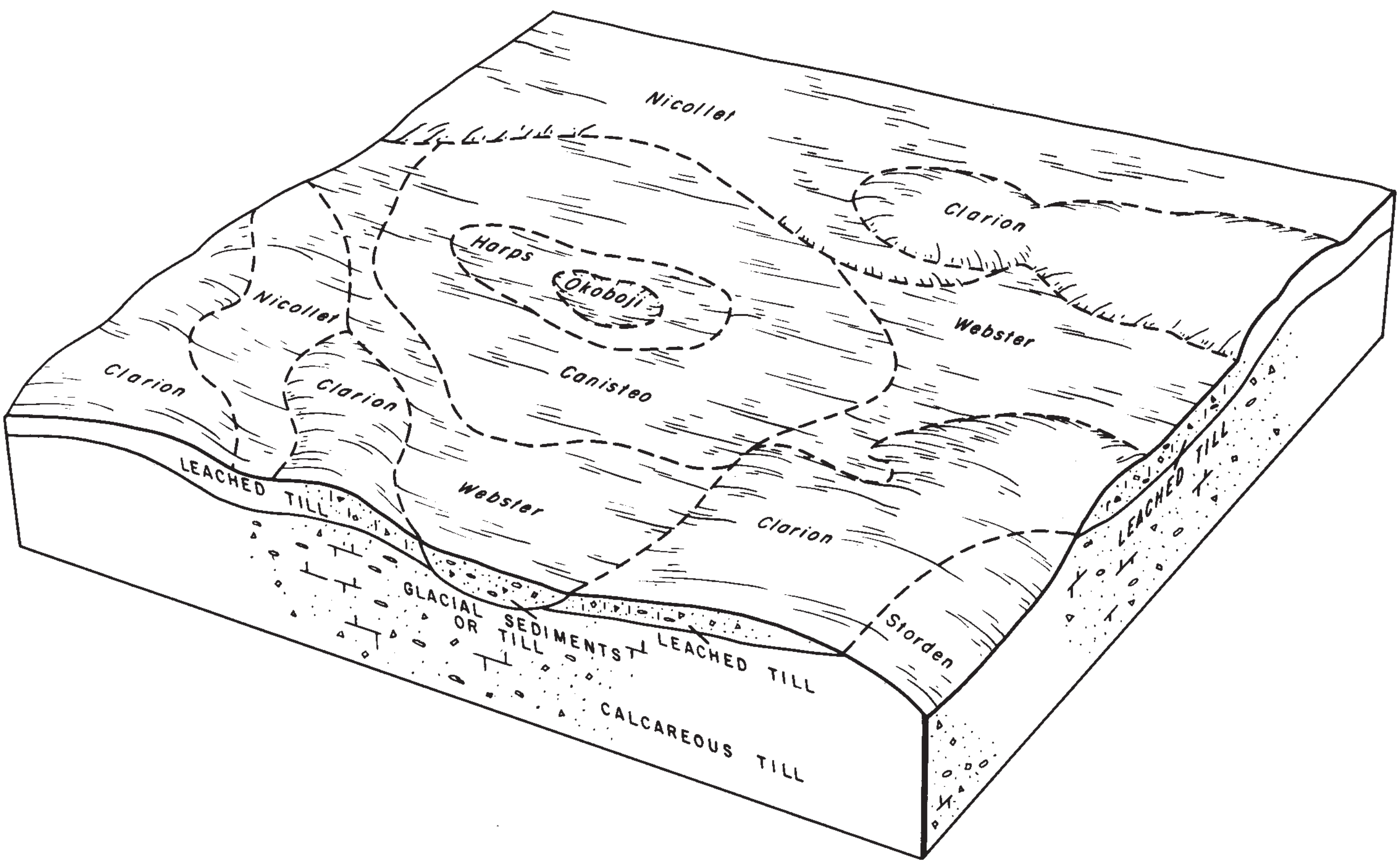


Figure 4.—Relationship of slope and parent material to soils of the Clarion-Nicollet-Canisteo association.

Corn, soybeans, small grain, and alfalfa grow well in the nearly level and gently sloping soils of this association, but the moderately sloping soils are only moderately well suited to row crops. The soils in this association have moderate or moderately slow permeability and high available water capacity. The content of organic matter is high in the surface layer in the nearly level soils, moderate or high in the gently sloping soils, and moderately low or moderate in the moderately sloping soils. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium in the surface layer generally ranges from very low to medium, and the content of available potassium in the subsoil generally is very low or low. Clarion, Nicollet, and Webster soils are slightly acid or neutral in the surface layer, and Canisteo soils are mildly alkaline or moderately alkaline in this layer. The major concerns of management for cropland are adequate erosion control on the gently sloping and moderately sloping soils and adequate drainage on the nearly level, poorly drained soils.

Nearly all areas of this association are used for cultivated crops, but a few areas of strongly sloping soils, a few undrained areas that are wet, and a few areas of droughty soils are used for permanent pasture. The main enterprises are growing cash crops and feeding hogs and beef cattle. The soils of the Clarion-Nicollet-Canisteo association are among the most productive in the county (fig. 5).

2. Sac-Primghar-Galva Association

Well-drained and somewhat poorly drained, moderately fine textured, nearly level to moderately sloping soils on loess-mantled uplands

The soils of this association are nearly level to moderately sloping silty clay loams. They are on a loess-mantled upland plain that is moderately dissected by drainageways and small streams. This plain generally has long, nearly level and gentle slopes, but some shorter moderate slopes are adjacent to the larger drainageways and stream valleys (fig. 6).

This association (fig. 7) occupies about 23 percent of the county. It is about 35 percent Sac soils, 30 percent Primghar soils, 20 percent Galva soils, 9 percent Marcus soils, and 6 percent minor soils.

Figure 5.—Corn and soybeans growing in the Clarion-Nicollet-Canisteo soil association. Nicollet loam and Clarion loam are in the foreground.

Figure 6.—Typical aerial view in the Sac-Primghar-Galva soil association. Sac silty clay loam, loam substratum, is in the foreground.

Sac soils are gently sloping and moderately sloping. The gently sloping soils generally are on long convex slopes, and the moderately sloping soils are on shorter convex slopes adjacent to the larger drainageways and stream valleys. Sac soils formed in thin loess that is generally 24 to 40 inches deep, and in the underlying glacial till. They are well drained and have a substratum of loam.

Primghar soils are nearly level and gently sloping. The nearly level soils generally are on broad flats, and the gently sloping soils generally are in long, narrow concave draws. Primghar soils formed in loess more than 40 inches thick. They are somewhat poorly drained.

The Galva soils in this association are nearly level and gently sloping. The nearly level soils occupy small convex slopes, and the gently sloping soils generally are on long convex slopes. Galva soils formed in loess more than 40 inches thick. They are well drained.

Marcus soils are nearly level. They are on broad flats and in narrow, concave draws. Marcus soils formed in loess more than 40 inches thick. They are poorly drained.

The minor soils in this association are in the Afton, Colo, Ely, Everly, Spillville, and Storden series.

The nearly level, poorly drained Colo soils occupy the stream valleys and larger drainageways; and the nearly level, poorly drained Afton soils occupy the small drainageways. The somewhat poorly drained Ely and Spillville soils are adjacent to the drainageways on gently sloping, concave foot slopes. The moderately sloping to very steep, loamy and calcareous, well-drained Storden soils occupy the short, steep slopes adjacent to the larger drainageways and stream valleys. Areas of the well-drained, gently sloping and moderately sloping, loamy Everly soils are intermingled with areas of the Sac soils.

Corn, soybeans, small grain, and alfalfa grow well in the nearly level and gently sloping soils of this association, but the moderately sloping soils are only moderately well suited to row crops. The soils in this association have moderate or

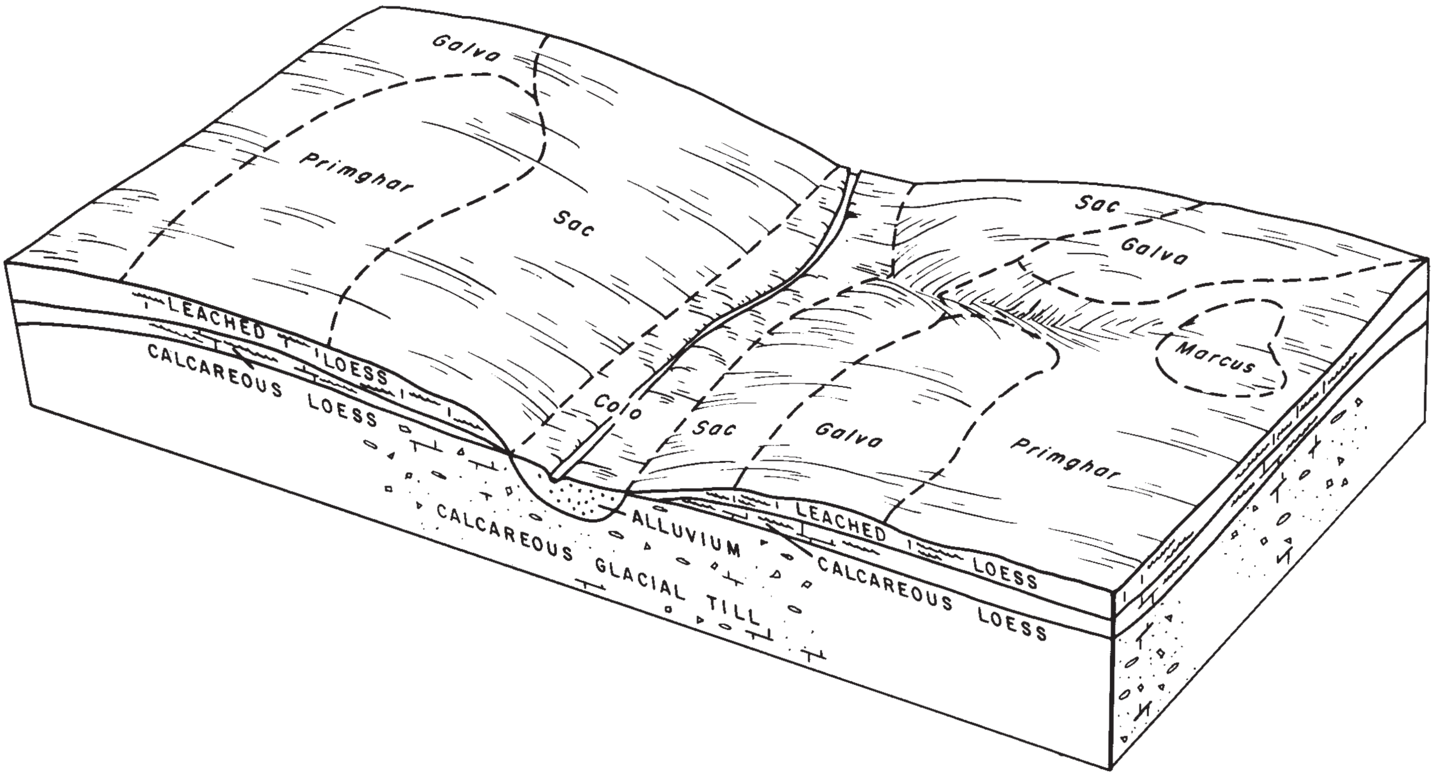


Figure 7.—**Relationship of slope and parent material to the soils of the Sac-Primghar-Galva association.**

moderately slow permeability and high available water capacity. The content of organic matter is high in the surface layer in the nearly level soils, moderate or high in the gently sloping soils, and moderately low or moderate in the moderately sloping soils. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium in the surface layer generally is medium or high, and the content of available potassium in the subsoil generally is very low or low. Unless they are limed, the dominant soils in this association are acid in the surface layer. The major concerns of management for cropland are adequate erosion control on the gently sloping and moderately sloping soils and adequate drainage on the nearly level, poorly drained soils.

Nearly all areas of this association are used for cultivated crops, but a few areas of steep soils and a few undrained areas that are wet are used for permanent pasture. The main enterprises are growing cash crops and feeding hogs and beef cattle. The soils of the Sac-Primghar-Galva association are among the most productive in the county.

3. Galva-Sac-Primghar Association

Well-drained and somewhat poorly drained, moderately fine textured, nearly level to moderately sloping soils on loess-mantled uplands

The soils of this association are nearly level to moderately sloping silty clay loams. They are on a loess-mantled upland plain that is moderately dissected by drainageways and small streams. This plain generally has long, nearly level and gentle slopes, but some areas of moderate slopes are adjacent to the larger drainageways and stream valleys.

This association occupies about 6 percent of the county. It is about 32 percent Galva soils, 30 percent Sac soils, 25 percent Primghar soils, and 13 percent minor soils.

Galva soils are gently sloping and moderately sloping. The gently sloping soils generally are on long convex slopes, and the moderately sloping soils are on moderately long convex slopes adjacent to the larger drainageways and stream valleys. These Galva soils formed in loess that is more than 40 inches thick. They are well drained.

Sac soils are gently sloping and moderately sloping. The gently sloping Sac soils generally are on long convex slopes, and the moderately sloping ones are on moderately long convex slopes adjacent to the larger drainageways and stream valleys. These Sac soils formed in loess that is 24 to 40 inches deep, and in the underlying glacial till. They are well drained and have a substratum of clay loam.

Primghar soils are nearly level and gently sloping. The nearly level soils generally are on broad flats, and the gently sloping soils generally are in long, narrow concave draws. These Primghar soils formed in loess that is more than 40 inches thick. They are somewhat poorly drained.

The minor soils in this association are in the Afton, Colo, Ely, Everly, and Marcus series.

The nearly level, poorly drained Colo soils occupy the larger drainageways and stream valleys, and the nearly level, poorly drained Afton and Marcus soils occupy the smaller drainageways. The somewhat poorly drained Ely soils are adjacent to the drainageways on gently sloping, concave foot slopes. Areas of the well-drained, gently sloping and the moderately sloping Everly soils are intermingled with areas of Sac soils.

Corn, soybeans, small grain, and alfalfa grow well in the nearly level and gently sloping soils of this association, but the moderately sloping soils are only moderately well suited

to row crops. These soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter is high in the surface layer in the nearly level soils, moderate or high in the gently sloping soils, and moderately low or low in the moderately sloping soils. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium in the surface layer generally is medium or high, and the content of available potassium in the subsoil generally is very low or low. Unless they are limed, the dominant soils in this association are acid in the surface layer. The major concern of management for cropland is adequate erosion control on the gently sloping and moderately sloping soils.

Nearly all areas of this association are used for cultivated crops, but a few are used for permanent pasture. The main enterprises are growing cash crops and feeding hogs and beef cattle.

4. Colo-Calco-Spillville Association

Poorly drained and somewhat poorly drained, moderately fine textured and medium-textured, nearly level and gently sloping soils on bottom lands

The soils of this association are nearly level and gently sloping silty clay loams and loams. They are on bottom lands that occupy stream valleys and larger drainageways.

This association occupies about 4 percent of the county. It is about 65 percent Colo soils, 15 percent Calco soils, 10 percent Spillville soils, and 10 percent minor soils.

Colo soils generally are nearly level, but they are gently sloping in many of the narrow stream valleys. They generally are adjacent to streams and larger drainageways. Colo soils formed in silty, moderately fine textured alluvium. They are poorly drained.

Calco soils are similar to Colo soils, but they are calcareous. Calco soils are nearly level. They generally are adjacent to large drainageways, especially near the heads of these drainageways. Calco soils formed in calcareous, silty, moderately fine textured alluvium. They are poorly drained.

Spillville soils are nearly level or gently sloping. They are on flood plains of streams and on low concave foot slopes below moderately sloping and strongly sloping soils. Spillville soils formed in loamy, medium-textured alluvium. They are somewhat poorly drained.

The minor soils in this association are in the Millington series.

The channeled, calcareous, poorly drained Millington soils, along with Colo and Spillville soils, occupy parts of the flood plain of Brooke Creek and Little Sioux River.

Corn, soybeans, small grain, and alfalfa grow well in the soils of this association that are not frequently flooded. The frequently flooded areas generally are channeled. The soils in this association that are dissected by many stream channels and are frequently flooded are poorly suited to row crops. All the soils in this association have moderate or moderately slow permeability and high available water capacity. The content of organic matter is high in the surface layer. The content of available phosphorus generally is medium in the surface layer in Colo and Spillville soils and very low, low, or medium in Calco soils. The content of available phosphorus in the underlying material generally is medium in Colo soils, low or medium in Spillville soils, and very low, low, or medium in Calco soils. The content of available potassium in the surface layer generally is medium in Colo and Spillville soils and very low, low, or medium in Calco soils. The content of available potassium in the underlying material generally is low or medium in Colo and Spillville soils and very low or low in Calco soils. Colo and Spillville soils are neutral or slightly acid in the surface layer, and Calco soils are mildly alkaline or moderately alkaline in this layer. The major concerns of management, for cropland, are adequate drainage and flood control.

The soils of this association are used for cultivated crops and pasture. The productivity of the cultivated areas depends on drainage and the frequency of flooding. The channeled areas generally are limited to pasture and scrub timber. Few farms lie entirely within this association. The main enterprises are growing cash crops and feeding hogs and beef cattle.

5. Wadena-Talcot-Cylinder Association

Well-drained to very poorly drained, medium-textured and moderately fine textured, nearly level to moderately sloping soils on outwash plains and terraces

The soils of this association are nearly level to moderately sloping loams and clay loams. They generally are on glacial outwash plains and stream terraces.

This association occupies about 3 percent of the county. It is about 40 percent Wadena soils, 16 percent Talcot soils, 14 percent Cylinder soils, and 30 percent minor soils.

Wadena soils are nearly level to moderately sloping. They generally are on convex slopes on glacial outwash plains and stream terraces. Wadena soils formed in loamy glacial outwash that is 24 to 40 inches thick over calcareous sand and gravel. They are well drained.

Talcot soils are nearly level. They are on low-lying flats in glacial outwash areas and on stream terraces. Talcot soils formed in calcareous, moderately fine textured glacial outwash that is 24 to 40 inches thick over calcareous sand and gravel. They are calcareous and very poorly drained.

Cylinder soils are nearly level. They generally are at intermediate elevations between the ridges of Wadena soils and the low-lying Talcot soils. Cylinder soils formed in loamy glacial outwash that is 24 to 40 inches thick over calcareous sand and gravel. They are somewhat poorly drained.

The minor soils in this association are in the Biscay, Canisteo, and Estherville series.

Small areas of the poorly drained, noncalcareous Biscay soils and areas of the poorly drained, calcareous Canisteo soils are on broad, low-lying flats in the glacial outwash areas. Small areas of the somewhat excessively drained Estherville soils are on ridges in glacial outwash areas and on stream terraces.

Corn, soybeans, small grain, and alfalfa grow well in the nearly level Wadena, Talcot, Cylinder, Biscay, and Canisteo soils and in the gently sloping Wadena soils (fig. 8). The gently sloping Estherville soils and the moderately sloping Estherville and Wadena soils are moderately well suited to row crops.

Wadena, Talcot, Cylinder, and Biscay soils have moderate or moderately slow permeability above the sand and gravel and have rapid or very rapid permeability in the sand and gravel. Canisteo soils have moderate permeability, and Estherville soils have moderately rapid or rapid permeability.

The moderately deep Wadena, Talcot, and Cylinder soils, have moderate or low available water capacity, and the

Figure 8.—**Cropland in the Wadena-Talcot-Cylinder soil association. Wadena, Talcot, Cylinder, Biscay, and Estherville soils are intermingled in the area in the foreground from the cornfield to the drainage ditch. Clarion-Nicollet-Canisteo-Webster soils are in the background.**

deep Wadena, Talcot, Cylinder, and Biscay soils have moderate available water capacity. Canisteo soils have high available water capacity, and Estherville soils have very low or low available water capacity.

The content of organic matter in the surface layer is moderate or high in the nearly level soils, and it ranges from moderate to very low in the gently sloping and moderately sloping soils. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil of soils in this association. The content of available potassium in the surface layer generally ranges from very low to medium, and the content of available potassium in the subsoil generally is very low or low. Unless limed, Wadena and Estherville soils generally are slightly acid in the surface layer. Talcot and Canisteo soils, generally are moderately alkaline in the surface layer, Cylinder and Biscay soils generally are neutral or slightly acid in this layer. The major concerns of management for cropland are the lack of available moisture, adequate erosion control on the gently sloping and moderately sloping soils, and adequate drainage on the nearly level, poorly drained soils.

The soils of this association are used for cultivated crops, meadow, and pasture. The main enterprises are growing cash crops and feeding hogs and beef cattle.

6. Waldorf-Collinwood-Clarion Association

Poorly drained to well-drained, medium-textured to fine-textured, nearly level to moderately sloping soils on uplands

The soils of this association are nearly level to moderately sloping loams and silty clay loams. They are on the Wisconsin (Cary) till plain in areas largely mantled by fine-textured lacustrine sediment.

This association occupies about 3 percent of the county. It is about 25 percent Waldorf soils, 20 percent Collinwood soils, 20 percent Clarion soils, 18 percent Nicollet soils, and 17 percent minor soils.

Waldorf soils are nearly level. They generally are on low-lying ground moraines on the Wisconsin (Cary) till plain. Waldorf soils formed in fine-textured lacustrine sediment. They have a moderately fine textured surface layer and a fine textured subsoil. They are poorly drained.

Collinwood soils are nearly level to moderately sloping. They are on broad flats and convex slopes on the undulating clay-mantled glacial till plain. Collinwood soils formed in fine-textured lacustrine sediment. They have a moderately fine textured surface layer and a fine-textured subsoil. They are somewhat poorly drained.

Clarion soils in this association are gently sloping or moderately sloping. They generally are on convex ridges or knobs on the glacial till plain. Clarion soils formed in loamy, calcareous glacial till. They are medium textured or moderately fine textured and are well drained.

Nicollet soils are nearly level. They generally are at intermediate elevations on the glacial till plain. Nicollet soils formed mainly in loamy glacial till. They are medium textured or moderately fine textured and are somewhat poorly drained.

The minor soils in this association are mainly in the Okoboji, Storden, and Webster series.

The very poorly drained Okoboji soils are in small, landlocked depressions. Areas of the moderately sloping or strongly sloping, calcareous, loamy Storden soils are intermingled with areas of the Clarion soils. Areas of the nearly level, poorly drained Webster soils are intermingled with areas of the Nicollet soils.

Corn, soybeans, small grain, and alfalfa grow well on the nearly level and gently sloping soils of the association, but the moderately sloping soils are only moderately well suited to row crops. Waldorf and Collinwood soils have moderately slow or slow permeability, and Clarion and Nicollet soils have moderate permeability. Most of the soils in this association have high available water capacity. The content of organic matter is high in the surface layer in the nearly level soils, moderate or high in the gently sloping soils, and moderately low or moderate in the moderately sloping soils. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium in the surface layer generally ranges from very low to medium, and the content of available subsoil potassium generally is very low or low. The soils in this association are slightly acid or neutral in the surface layer. The major concerns of management for cropland are erosion control on the gently sloping and moderately sloping soils and drainage on the nearly level, poorly drained soils.

Nearly all areas of this association are used for cultivated crops, but a few areas of moderately sloping and strongly sloping soils are used for permanent pasture. The main enterprises are growing cash crops and feeding hogs and beef cattle.

7. Storden Association

Somewhat excessively drained, medium-textured, moderately sloping to very steep soils on uplands

The soils of this association are moderately sloping to very steep loams. They are on Wisconsin till plains (Tazewell and Cary) on slopes generally adjacent to bottom lands along the Little Sioux River and its larger tributaries.

This association occupies about 2 percent of the county. It is about 90 percent Storden soils and 10 percent minor soils (fig. 9).

Figure 9.—**View of the Storden soil association in the northwest part of the county. Generally Storden soils with some Lester soils are in the wooded areas, and Terril soils are on the foot slopes. Colo, Spillville, and Millington soils occupy the drainageways that are part of the Colo-Calco-Spillville association.**

Storden soils are moderately sloping to very steep. They are on slopes adjacent to bottom lands along the larger streams. Storden soils formed in loamy, calcareous glacial till. They are calcareous and somewhat excessively drained.

The minor soils in this association are in the Lester and Terril series. The well-drained Lester soils generally are in steep and very steep wooded areas. The loamy, well-drained Terril soils generally are on moderately sloping foot slopes below areas of the strongly sloping to very steep Storden soils.

In most areas the soils of this association are either poorly suited or unsuited to cultivated crops (fig. 10). The soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from moderately low to very low. The content of available phosphorus generally is very low or low in the surface layer of Storden soils and very low in the underlying material. The content of available potassium in the surface layer generally is low, and the content of available potassium in the underlying material generally is very low. Storden soils are mildly alkaline or moderately alkaline in the surface layer.

These soils generally are used for wooded or are left as wooded areas. Many of the wooded areas are grazed.

Descriptions of the Soils

The soil series and mapping units in Buena Vista County are described in this section. A soil series is described in detail and then, briefly, each mapping unit in that series is described. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Fill land and Marsh, for example, do not belong to a soil series, but they are listed in alphabetic order along with the soil series. Color terms are for moist soil unless otherwise stated.

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and the environmental planting group in which the mapping unit has been placed. The page for the description of each mapping unit is given, and each environmental planting group is found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the "Glossary," and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual *(10)*[1].

Afton Series

The Afton series consists of poorly drained soils in upland drainageways or on low concave foot slopes adjacent to drainageways. These soils formed in loess and local alluvium under a native vegtation of swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 30 inches thick. It is black silty clay loam in the upper part and very dark gray silty clay loam in the lower part. The subsoil extends to a depth of 46 inches. It is olive-gray, friable silty clay loam. The substratum is olive-gray silty clay loam.

Afton soils have moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is low in the surface layer and very low in the subsoil. The content of available potassium generally is medium in the surface layer and very low or low in the subsoil. Reaction generally is neutral in the surface layer.

Afton soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Afton silty clay loam, 0 to 2 percent slopes, 100 feet south and 500 feet west of the northeast corner of NW1/4 sec. 22, T. 92 N., R. 38 W.:

A11—0 to 5 inches, black (10YR 2/1) heavy silty clay loam; moderate, fine and medium, granular structure; friable; many roots; neutral; gradual, smooth boundary.

A12—5 to 16 inches, black (10YR 2/1) heavy silty clay loam; moderate, fine and medium, subangular blocky structure parting to moderate, fine and medium, granular; friable; many roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

A13—16 to 24 inches, black (10YR 2/1) heavy silty clay loam; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few

[1] Italic numbers in parentheses refer to Literature Cited, p. 89.

Figure 10.—The pastures in this area are strongly sloping to very steep Storden soils. The cropland is sloping to moderately sloping Sac and Galva soils.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Mapping unit	Acres	Percent
Afton silty clay loam, 0 to 2 percent slopes	2,100	0.6
Biscay clay loam, deep, 0 to 2 percent slopes	825	.2
Blue Earth mucky silt loam, 0 to 1 percent slopes	2,325	.6
Calco silty clay loam, 0 to 2 percent slopes	2,270	.6
Canisteo silty clay loam, 0 to 2 percent slopes	45,910	12.5
Clarion loam, 2 to 5 percent slopes	53,130	14.6
Clarion loam, 5 to 9 percent slopes, moderately eroded	12,280	3.3
Clarion loam, 9 to 14 percent slopes, moderately eroded	370	.1
Clarion silty clay loam, 2 to 5 percent slopes	1,905	.5
Collinwood silty clay loam, 0 to 2 percent slopes	1,815	.5
Collinwood silty clay loam, 2 to 5 percent slopes	440	.1
Collinwood silty clay loam, 5 to 9 percent slopes	245	.1
Colo silty clay loam, 0 to 2 percent slopes	8,015	2.2
Colo-Spillville complex, 2 to 5 percent slopes	1,615	.4
Colo-Spillville complex, channeled, 0 to 2 percent slopes	2,725	.7
Cylinder loam, deep, 0 to 2 percent slopes	910	.2
Cylinder loam, moderately deep, 0 to 2 percent slopes	1,235	.3
Dickinson fine sandy loam, 2 to 5 percent slopes	390	.1
Ely silty clay loam, 2 to 5 percent slopes	510	.1
Estherville sandy loam, 2 to 5 percent slopes	870	.2
Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	255	.1
Everly clay loam, 2 to 5 percent slopes	555	.2
Everly clay loam, 5 to 9 percent slopes	240	.1
Everly clay loam, 5 to 9 percent slopes, moderately eroded	630	.2
Fill land	120	([1])
Galva silty clay loam, 0 to 2 percent slopes	850	.2
Galva silty clay loam, 2 to 5 percent slopes	24,410	6.7
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	315	.1
Galva silty clay loam, benches, 1 to 3 percent slopes	305	.1
Gravel pits	460	.1
Harps loam, 0 to 2 percent slopes	2,890	.8
Lanyon silty clay loam, 0 to 1 percent slopes	565	.2
Lester loam, 18 to 25 percent slopes	270	.1
Lester loam, 25 to 40 percent slopes	290	.1
Marcus silty clay loam, 0 to 2 percent slopes	8,870	2.4

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Mapping unit	Acres	Percent
Marsh	105	(1)
Millington loam, channeled, 0 to 2 percent slopes	600	.2
Nicollet loam, 1 to 3 percent slopes	48,225	13.1
Nicollet silty clay loam, 1 to 3 percent slopes	1,530	.4
Okoboji silty clay loam, 0 to 1 percent slopes	8,460	2.3
Primghar silty clay loam, 0 to 2 percent slopes	19,300	5.3
Primghar silty clay loam, 2 to 4 percent slopes	12,420	3.4
Rolfe silt loam, 0 to 1 percent slopes	130	(1)
Sac silty clay loam, loam substratum, 2 to 5 percent slopes	30,090	8.2
Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	2,295	.7
Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	3,530	1.0
Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded	1,645	.4
Salida gravelly sandy loam, 5 to 9 percent slopes	340	.1
Salida gravelly sandy loam, 9 to 14 percent slopes	260	.1
Spicer silty clay loam, 0 to 2 percent slopes	360	.1
Spillville loam, 0 to 2 percent slopes	825	.2
Spillville loam, 2 to 5 percent slopes	1,780	.5
Storden loam, 5 to 9 percent slopes	1,495	.4
Storden loam, 9 to 14 percent slopes	1,855	.5
Storden loam, 14 to 18 percent slopes	950	.3
Storden loam, 18 to 25 percent slopes	1,405	.4
Storden loam, 25 to 40 percent slopes	2,505	.7
Talcot clay loam, deep, 0 to 2 percent slopes	2,190	.6
Talcot clay loam, moderately deep, 0 to 2 percent slopes	265	.1
Terril loam, 4 to 9 percent slopes	670	.2
Wacousta mucky silt loam, 0 to 1 percent slopes	430	.1
Wadena loam, deep, 1 to 5 percent slopes	430	.1
Wadena loam, moderately deep, 0 to 2 percent slopes	1,325	.4
Wadena loam, moderately deep, 2 to 5 percent slopes	4,365	1.2
Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	820	.2
Waldorf silty clay loam, 0 to 2 percent slopes	3,375	.9
Webster silty clay loam, 0 to 2 percent slopes	31,470	8.6
Total	366,355	100.0

[1] Less than 0.05 percent.

strong-brown oxides along root channels; neutral; gradual, smooth boundary.

A3g—24 to 30 inches, very dark gray (10YR 3/1) silty clay loam; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, medium, prismatic structure parting to weak and moderate, fine and medium, subangular blocky; friable; common roots; common very fine and fine tubular pores; neutral; gradual, wavy boundary.

B21g—30 to 38 inches, olive-gray (5Y 5/2) silty clay loam; common, fine and medium, faint mottles of light olive gray (5Y 6/2) and light olive brown (2.5Y 5/4); thin, discontinous coatings of very dark gray (10YR 3/1) on peds; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; few roots; common very fine and fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; mildly alkaline; gradual, smooth boundary.

B22g—38 to 46 inches, olive-gray (5Y 5/2) silty clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; few roots; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; mildly alkaline; gradual, smooth boundary.

C1g—46 to 50 inches, olive-gray (5Y 5/2) light silty clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); weak, medium, subangular blocky structure; friable; few roots; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; mildly alkaline; gradual, wavy boundary.

C2g—50 to 60 inches, olive-gray (5Y 5/2) light silty clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); massive; friable; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 40 to 54 inches. Depth to glacial till generally is 40 to 80 inches. The A1 horizon is black (10YR 2/1 or N 2/0) and is 18 to 28 inches thick. The A3 horizon is very dark gray (10YR 3/1 or 5Y 3/1) and is 4 to 10 inches thick. Reaction in the A horizon ranges from slightly acid to mildy alkaline.

The B horizon is 14 to 24 inches thick. The B2 horizon is dark gray (5Y 4/1), olive gray (5Y 5/2), or gray (5Y 5/1). The B3 horizon, if present, is silty clay loam or silt loam. Reaction in the B horizon is mildly alkaline or moderately alkaline.

Afton soils, like the Marcus and Colo soils, are poorly drained, and they have profiles that are somewhat similar to the ones of those soils. They have a thicker A horizon, however, than that of Marcus soils. The gray material is not so deep in Afton soils as it is in Colo soils, and Afton soils have more clay in the A horizon than those soils.

31—Afton silty clay loam, 0 to 2 percent slopes. This nearly level soil is in upland drainageways or on low, concave foot slopes adjacent to the drainageways. Areas of this soil are long and narrow in shape and range from 5 to 40 acres in size.

Included with this soil in mapping are small areas of soils that are calcareous throughout. In places depth to glacial till is less than 40 inches.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to corn, soybeans, small grain, and alfalfa. Occasionally this soil is damaged by overflow from streams. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw-2; environmental planting group 2.

Biscay Series

The Biscay series consists of poorly drained, low-lying soils in glacial outwash areas and on stream terraces. These soils formed in glacial outwash underlain by sand and gravel at a depth of 32 to 40 inches under a native vegetation of swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 23 inches thick. It is black clay loam in the upper part and very dark gray and very dark grayish-brown clay loam in the lower part. The subsoil extends to a depth of 35 inches. It is olive-gray, friable sandy clay loam. The substratum is mixed light olive-brown and grayish-brown sand and gravel.

Biscay soils have moderate permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. They have moderate available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in both the surface layer and in the subsoil. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. Reaction generally is neutral in the surface layer.

Biscay soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Biscay clay loam, deep, 0 to 2 percent slopes, 250 feet north and 580 feet west of the southeast corner of NE1/4 sec. 34, T. 91 N., R. 37 W.:

Ap—0 to 9 inches, black (N 2/0) clay loam; weak, fine and medium, granular structure; friable; many roots; common very fine and fine tubular pores; common small pebbles; neutral; abrupt, smooth boundary.

A12—9 to 14 inches, black (10YR 2/1) clay loam; weak, fine and medium, subangular blocky structure parting to moderate, fine and medium, granular; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A31g—14 to 18 inches, very dark gray (10YR 3/1) clay loam; common, fine, faint mottles of dark olive gray (5Y 3/2); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A32g—18 to 23 inches, very dark grayish-brown (2.5Y 3/2) clay loam; common, fine, faint mottles of olive gray (5Y 4/2 and 5Y 5/2); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few fine segregations and concretions of iron and manganese oxides; common small pebbles; neutral; gradual, smooth boundary.

B2g—23 to 29 inches, olive-gray (5Y 5/2) sandy clay loam; common, fine, faint mottles of olive gray (5Y 4/2) and dark olive gray (5Y 3/2); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small pebbles; neutral; gradual, smooth boundary.

B3g—29 to 35 inches, olive-gray (5Y 5/2) sandy clay loam; common, fine, faint mottles of olive gray (5Y 4/2) and light olive gray (5Y 6/2); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small pebbles; mildly alkaline; clear, wavy boundary.

IIC—35 to 60 inches, mixed light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) sand and gravel; single grained; loose; few roots; common fine and medium segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 32 to 40 inches. Depth to sand and gravel also ranges from 32 to 40 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). It is dominantly clay loam, but it ranges from silty clay loam to loam. The A horizon is 14 to 24 inches thick. Reaction in the A horizon generally is neutral, but it ranges from slightly acid to mildly alkaline.

The B2 horizon ranges from dark gray (2.5Y 4/1 or 5Y 4/1) to olive gray (5Y 5/2). It is clay loam, loam, or sandy clay loam. Reaction in the B2 horizon generally is neutral or mildly alkaline.

The IIC horizon generally is sand and gravel or sand. In places, however, it is loamy sand or gravelly loamy sand.

Biscay soils are associated with Cylinder and Talcot soils and have drainage similar to that of Webster soils. They have a grayer B horizon than that of Cylinder soils. Unlike Talcot soils, Biscay soils have a noncalcareous solum. Unlike Webster soils, Biscay soils are underlain by sand and gravel at a depth of 32 to 40 inches.

259—Biscay clay loam, deep, 0 to 2 percent slopes. This nearly level soil is in glacial outwash areas and on stream terraces. It has sand and gravel at a depth of 32 to 40 inches. Areas are irregular in shape and generally range from 10 to 50 or more acres in size.

Included with this soil in mapping are areas of soils that are less than 32 inches deep to sand and gravel and areas of soils that are more than 40 inches deep to sand and gravel. Also included are small areas of Talcot soils which are calcareous throughout.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to corn, soybeans, small grain, and alfalfa. It has a seasonal high water table and is susceptible to a slight hazard of drought in dry years. Wetness is a moderate limitation in cultivated areas that are artificially drained and a severe limitation in areas that are not artificially drained. Capability unit IIw-3; environmental planting group 2.

Blue Earth Series

The Blue Earth series consists of calcareous, very poorly drained, depressional soils in small, shallow glacial lake basins. These soils formed in silty, waterworked glacial sediment or local alluvium under a native vegetation of swamp grasses and sedges. Slopes range from 0 to 1 percent.

In a representative profile the surface layer extends to a depth of 44 inches. It is black mucky silt loam in the upper part, black silty clay loam in the middle part, and black silt loam in the lower part. The underlying material is very dark gray silt loam.

Blue Earth soils have moderate or moderately slow permeability and high or very high available water capacity. The content of organic matter in the surface layer is very high. The content of available phosphorus generally is very low or low in the surface layer and very low in the underlying material. The content of available potassium ranges from very low to medium in the surface layer and generally is very low or low in the underlying material. Reaction is moderately alkaline or mildly alkaline in the surface layer.

Blue Earth soils are used mainly for cultivated crops. The major limitations are wetness and ponding.

Representative profile of Blue Earth mucky silt loam, 0 to 1 percent slopes, in a cultivated field 520 feet south and 520 feet west of the northeast corner of SE1/4 sec. 36, T. 91 N., R. 36 W.:

Ap—0 to 10 inches, black (N 2/0) mucky silt loam; moderate, fine and medium, granular structure; friable; many roots; few fine fragments of snail shells; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12—10 to 16 inches, black (N 2/0) mucky silt loam; weak, very fine and fine, subangular blocky structure and moderate, fine and

medium, granular; friable; common roots; few fine fragments of snail shells; slight effervescence; moderately alkaline; clear, smooth boundary.

A13—16 to 22 inches, black (N 2/0) silty clay loam; weak, fine and medium, subangular blocky structure; friable; common roots; slight effervescence; moderately alkaline; clear, smooth boundary.

A14—22 to 26 inches, black (10YR 2/1) light silty clay loam; common, medium, distinct mottles of dark grayish brown (2.5Y 4/2); very weak, medium, subangular blocky structure; friable; common roots; slight effervescence; moderately alkaline; clear, smooth boundary.

A15—26 to 36 inches, black (10YR 2/1) silt loam; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2); massive; friable; few roots; many fine and medium fragments of snail shells; strong effervescence; moderately alkaline; gradual, smooth boundary.

A16—36 to 44 inches, black (10YR 2/1) silt loam; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2); weak, medium, subangular blocky structure; friable; few roots; many fine and medium fragments of snail shells; strong effervescence; moderately alkaline; gradual, smooth boundary.

C1—44 to 68 inches, very dark gray (5Y 3/1) silt loam; common, fine, faint mottles of dark olive gray (5Y 3/2); massive; friable; many fine and medium fragments of snail shells; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—68 to 84 inches, very dark gray (5Y 3/1) silt loam; common, fine, faint mottles of dark gray (5Y 3/2); massive; friable; common fine fragments of snail shells; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 28 to 48 inches. The A horizon is mucky silt loam, mucky silty clay loam, silt loam, or silty clay loam and is 28 to 48 inches thick. Reaction in the A horizon is moderately alkaline or mildly alkaline.

The C horizon ranges from black (5Y 2/1) to gray (5Y 5/1) and from very dark grayish brown (2.5Y 3/2) to light olive brown (2.5Y 5/4). It is silt loam, silty clay loam, clay loam, or loam.

Blue Earth soils, like the associated Canisteo, Okoboji, and Wacousta soils, are poorly drained or very poorly drained. They have a higher content of organic matter in the A horizon than Canisteo and Wacousta soils. Unlike Okoboji and Wacousta soils, Blue Earth soils have a calcareous A horizon. They have less clay in the solum than Okoboji soils.

511—Blue Earth mucky silt loam, 0 to 1 percent slopes. This depressional soil is in small, shallow glacial lake basins. Areas of this soil are irregular in shape and generally range from 10 to 60 acres in size.

Included with this soil in mapping are small areas of soils that have a surface layer less than 28 inches thick. Also included are areas of soils in which the lower part of the surface layer is mainly heavy silty clay loam or silty clay.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is moderately suited to corn, soybeans, small grain, and alfalfa. It is highly susceptible to ponding and generally has a very high water table. In cultivated areas this soil has a severe limitation because of wetness. Capability unit IIIw–2; environmental planting group 2.

Calco Series

The Calco series consists of calcareous, poorly drained soils on bottom lands. These soils formed in moderately fine textured silty alluvium under a native vegetation of swamp grasses, sedges, and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 36 inches thick. The underlying material is very dark gray silty clay loam.

Calco soils have moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus ranges from very low to low in both the surface layer and in the underlying material. The content of available potassium ranges from very low to low in the surface layer and is very low or low in the underlying material. Reaction is moderately alkaline in the surface layer.

Calco soils are used mainly for cultivated crops and pasture. The major limitations in cultivated areas are wetness and occasional flooding.

Representative profile of Calco silty clay loam, 0 to 2 percent slopes, in a cultivated field 894 feet north and 1,573 feet east of the southwest corner of sec. 20, T. 92 N., R. 38 W.:

Ap—0 to 9 inches, black (N 2/0) silty clay loam; moderate, very fine and fine, granular structure; friable; many roots; few fine tubular pores; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12—9 to 17 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure parting to moderate, fine, granular; friable; common roots; common fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

A13—17 to 24 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure parting to moderate, fine, granular; friable; few roots; common fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

A14—24 to 36 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure; friable; few roots; common fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

Cg—36 to 60 inches, very dark gray (10YR 3/1) silty clay loam; massive; friable; few fine tubular pores; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 36 to 50 inches. The A1 horizon is silty clay loam or heavy silt loam. Reaction in the A1 horizon is moderately alkaline or mildly alkaline. The A horizon is 30 to 40 inches thick.

A Bg horizon is present in places. It is very dark gray (10YR 3/1, N 3/0, or 5Y 3/1) or dark gray (10YR 4/1 or 4/0). Reaction in the Bg horizon, if one is present, is moderately alkaline or mildly alkaline.

The Cg horizon ranges from very dark gray (10YR 3/1) to gray (5Y 5/1) or olive gray (5Y 5/2). It is silty clay loam or clay loam, and in places, below a depth of 48 inches, it is sandy loam. Reaction in the Cg horizon is also moderatley alkaline or mildly alkaline.

Calco soils, like associated Colo soils, are poorly drained. Unlike Colo soils, Calco soils have a calcareous solum.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level soil is generally on narrow bottom lands. Areas of this soil are long and narrow and generally range from 10 to 80 or more acres in size.

Included with this soil in mapping are areas of soils that have a surface layer less than 36 inches thick. Also included are a few areas of soils in which the lower part of the surface layer is mainly heavy silty clay loam or silty clay.

Most areas of this soil are cultivated. Where drainage is adequate and flooding is controlled, the soil is well suited to crops. Occasionally this soil is damaged by overflow. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw–1; environmental planting group 2.

Canisteo Series

The Canisteo series consists of calcareous, poorly drained soils on low-lying flats of the Wisconsin (Cary) till plain. These soils formed in glacial till or waterworked glacial sediment under a native vegetation of swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 23 inches thick. It is a black silty clay loam in the upper part,

black clay loam in the middle part, and very dark gray clay loam in the lower part. The subsoil of friable clay loam extends to a depth of 34 inches. It is dark gray in the upper part and olive gray in the lower part. The substratum is olive-gray clay loam and silty clay loam.

Canisteo soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorous is very low in both the surface layer and in the subsoil. The content of available potassium ranges from very low to low in the surface layer and is very low or low in the subsoil. Reaction is moderately alkaline in the surface layer.

Canisteo soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Canisteo silty clay loam, 0 to 2 percent slopes, in a cultivated field 50 feet north and 640 feet west of the southeast corner of SW1/4 sec. 18, T. 91 N., R. 35 W.:

Ap—0 to 10 inches, black (N 2/0) silty clay loam; moderate, fine and medium, granular structure; friable; many roots; common small pebbles; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12—10 to 18 inches, black (10YR 2/1) clay loam; moderate, very fine and fine, subangular blocky structure parting to moderate, fine and medium, granular; friable; many roots; common very fine tubular pores; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

A3g—18 to 23 inches, very dark gray (10YR 3/2) clay loam; few, fine, faint mottles of very dark grayish brown (10YR 3/2); thin, discontinuous, black (10YR 2/1) coatings on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

B21g—23 to 28 inches, dark-gray (10YR 4/1) clay loam; thin, discontinuous very dark gray (10YR 3/1) and black (10YR 2/1) coatings on peds; weak, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

B22g—28 to 34 inches, olive-gray (5Y 5/2) clay loam; common, fine, faint mottles of dark gray (5Y 4/1); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few fine segregations and concretions of iron and manganese oxides; few fine segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline; gradual, smooth boundary.

C1—34 to 46 inches, olive-gray (5Y 5/2) clay loam; few, fine, faint mottles of dark gray (5Y 4/1); massive; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; few fine segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline; gradual, smooth boundary.

C2—46 to 48 inches, olive-gray (5Y 5/2) silty clay loam; few, fine, faint mottles of dark gray (5Y 4/1); massive; friable; few roots; common fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

C3—48 to 60 inches, olive-gray (5Y 5/2) clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6), dark gray (5Y 4/1), light olive gray (5Y 6/2), and strong brown (7.5YR 5/6); massive; friable; common fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 20 to 36 inches. The A1 horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is silty clay loam or clay loam. The A horizon is 12 to 24 inches thick. Reaction in the A horizon is mildly alkaline or moderately alkaline.

The B2g horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2) or grayish brown (2.5Y 5/2). It is clay loam or heavy loam. Reaction in the B horizon is mildly alkaline or moderately alkaline.

The C horizon ranges from olive gray (5Y 5/2) to light olive gray (5Y 6/2) to light olive brown (2.5Y 5/4). It generally is clay loam or loam.

Canisteo soils, like the associated Webster soils, are poorly drained. Unlike Webster soils, they have a calcareous solum.

507—Canisteo silty clay loam, 0 to 2 percent slopes. This nearly level soil is on low-lying till plains. Areas of this soil are irregular in shape and generally range from 10 to 100 or more acres in size.

Included with this soil in mapping are small areas of Harps, Okoboji, and Clarion soils.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to corn, soybeans, small grain, and alfalfa. It has excess lime in the surface layer and has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw-2; environmental planting group 2.

Clarion Series

The Clarion series consists of well-drained soils that generally are on irregular convex ridges of the Wisconsin (Cary) till plain. Slopes are generally short. Some Clarion soils, however, are on smoother landscapes and have moderately long convex slopes. The Clarion soils formed in loamy, calcareous glacial till or sediment derived from glacial till under a native vegetation of prairie grasses. Slopes range from 2 to 14 percent.

In a representative profile the surface layer is about 16 inches thick. It is black loam in the upper part and very dark brown loam in the lower part. The subsoil is brown, friable loam that extends to a depth of 32 inches. The substratum is yellowish-brown light clay loam and loam (fig. 11).

Clarion soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from moderately low to high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

Clarion soils are used mainly for cultivated crops. The major limitation in cultivated areas is erosion.

Representative profile of Clarion loam, 2 to 5 percent slopes, in a cultivated field 1,545 feet north and 70 feet west of the southeast corner of sec. 20, T. 91 N., R. 35 W.:

Ap—0 to 10 inches, black (10YR 2/1) loam; moderate, fine and medium, granular structure; friable; many roots; common small pebbles; neutral; abrupt, smooth boundary.

A3—10 to 16 inches, very dark brown (10YR 2/2) loam; common, fine, faint mottles of very dark grayish brown (10YR 3/2); thin, discontinuous black (10YR 2/1) coatings on peds; weak, fine, subangular blocky structure; friable; common roots; few fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B21—16 to 21 inches, brown (10YR 4/3) loam; thin, discontinuous very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) coatings on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B22—21 to 32 inches, brown (10YR 4/3) loam; thin, discontinuous very dark grayish brown (10YR 3/2) coatings on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; clear, wavy boundary.

C1—32 to 40 inches, yellowish-brown (10YR 5/4) light clay loam; common, fine, distinct mottles of grayish brown (10YR 5/2), brown (10YR 4/3), and yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; friable; few roots; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—40 to 46 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) light clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); massive; friable; few fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C3—46 to 84 inches, yellowish-brown (10YR 5/6) loam; common, fine and medium, distinct mottles of grayish brown (10YR 5/2), light brownish gray (10YR 6/2), yellowish brown (10YR 5/4), and strong brown (7.5YR 5/6); massive; friable; few fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small and medium pebbles; strong effervescence; moderately alkaline.

Thickness of the solum generally ranges from 24 to 40 inches. In places, however, it ranges from 18 to 50 inches. Depth to carbonates generally ranges from 24 to 40 inches. The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It is dominantly loam, but in places it is silty clay loam, sandy loam, or light clay loam. Unless eroded, the A horizon is 10 to 16 inches thick. Reaction in the A horizon is lightly acid or neutral.

The B horizon is loam or light clay loam and is 8 to 30 inches thick. The B1 horizon, if present, is very dark brown (10YR 3/3) or brown (10YR 4/3). The B2 horizon is brown (10YR 4/3) or yellowish brown (10YR 4/4). The B3 horizon, if present, is brown (10YR 4/3) or dark yellowish brown (10YR 5/4 or 5/6).

The C horizon is yellowish brown (10YR 5/4 or 5/6), grayish brown (10YR 5/2), or light olive brown (2.5Y 5/4).

In mapping unit 250B, the A horizon is silty clay loam or medium clay loam, and the B2 horizon is clay loam or loam. The soils in this mapping unit have more silt and slightly more clay in the A and B horizons than defined as the range for the series, but this difference does not significantly affect their use or behavior.

Clarion soils are associated with Nicollet and Storden soils, and they formed in similar parent material. They have a browner B horizon and a slightly thinner A horizon than those of Nicollet soils. Unlike Storden soils that are calcareous at or near the surface, Clarion soils are noncalcareous in the upper 24 inches of the profile.

Figure 11.—**Harvested cornfield on Clarion loam with soil profile exposed by recent road cut.**

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping soil is on irregular convex ridges on glacial till uplands. Areas of this soil generally are irregular in shape and generally range from 4 to 30 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are small areas of Estherville, Salida, and Storden soils.

Most areas of this soil are cultivated. Where erosion is controlled, the soil is well suited to crops. It is moderately susceptible to erosion. The content of organic matter in the surface layer is moderate or high. Capability unit IIe–1; environmental planting group 1.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil generally is on irregular convex ridges on glacial till uplands. Areas of this soil are irregular or long and narrow in shape and range from 2 to 20 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. In most places some subsoil material has been mixed in the surface layer. Included in mapping are areas of soils that have a surface layer of silty clay loam or clay loam. Also included are small areas of Estherville, Salida, and Storden soils.

Most areas of this soil are used for cultivated crops. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–1; environmental planting group 1.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on convex side slopes on glacial till uplands. Areas are irregular or long and narrow in shape and range from 2 to 10 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. In most places subsoil material has been mixed in the surface layer. Included in mapping are small areas of Estherville, Salida, and Storden soils.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–2; environmental planting group 1.

250B—Clarion silty clay loam, 2 to 5 percent slopes. This soil has moderately long, convex, gentle slopes. It is on glacial till uplands. Areas of this soil are irregular in shape and generally range from 4 to 50 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is silty clay loam or clay loam and the subsoil is clay loam. It formed in sediment derived from glacial till or partly in the sediment and partly in the underlying glacial till. Included in mapping are small areas of Nicollet, Collinwood, and Storden soils.

Most areas of this soil are cultivated. Where erosion is controlled, the soil is well suited to row crops. It is moderately susceptible to erosion. The content of organic matter in the surface layer is moderate or high. Capability unit IIe-1; environmental planting group 1.

Collinwood Series

The Collinwood series consists of somewhat poorly drained soils that have convex slopes. These soils are on the undulating Wisconsin (Cary) till plain. They formed in fine-textured lacustrine sediment under a native vegetation of prairie grasses. Slopes range from 0 to 9 percent.

In a representative profile the surface layer is about 15 inches thick. It is black silty clay loam in the upper part and black silty clay in the lower part. The subsoil of firm silty clay extends to a depth of 37 inches. It is mixed dark grayish brown and very dark grayish brown in the upper part, dark grayish-brown in the middle part, and grayish-brown in the lower part. The substratum is grayish-brown silty clay to a depth of 48 inches and mixed yellowish-brown and grayish-brown silty clay below.

Collinwood soils have slow permeability and high available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium is low or medium in the surface layer and very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

The Collinwood soils are used mainly for cultivated crops and pasture. The major limitations in cultivated areas or pasture are the clayey texture, wetness, and erosion.

Representative profile of Collinwood silty clay loam, 0 to 2 percent slopes, in a cultivated field 525 feet south and 657 feet east of the northwest corner of sec. 16, T. 93 N., R. 37 W.:

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; cloddy parting to fine and medium, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silty clay; few peds of very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2); moderate, very fine and fine, subangular blocky structure; firm; common roots; common fine tubular pores; few fine segregations of yellowish-brown (10YR 4/4) and dark-brown (7.5YR 4/4) iron and manganese oxides; neutral; gradual, smooth boundary.

B1—15 to 21 inches, mixed dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (10YR 3/2) silty clay; thin coatings of very dark gray (10YR 3/1) and black (10YR 2/1) on peds; moderate, fine, subangular blocky structure; firm; common roots; common fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

B2—21 to 25 inches, dark grayish-brown (2.5Y 4/2) silty clay; common, fine and medium, distinct mottles of brown (10YR 4/3); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; moderate, fine, subangular blocky structure; firm; common roots; common fine tubular pores; few fine segregations and concretions of dark yellowish-brown (10YR 4/4) to yellowish-brown (10YR 5/6) iron and manganese oxides; neutral; clear, wavy boundary.

B3—25 to 37 inches, grayish-brown (2.5Y 5/2) silty clay; common, fine and medium, faint and distinct mottles of dark grayish brown (2.5Y 4/2) and yellowish brown (10YR 5/6); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds in upper part; weak, fine and medium, subangular blocky structure; firm; few roots; few fine tubular pores; few fine segregations and concretions of yellowish-brown (10YR 5/6) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline; gradual, smooth boundary.

C1—37 to 48 inches, grayish-brown (2.5Y 5/2) silty clay; common, fine and medium, faint and distinct mottles of light brownish gray (2.5Y 4/2), and yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; firm; few roots; few fine tubular pores; common fine segregations and concretions of yellowish-brown (10YR 5/6) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—48 to 56 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) silty clay; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6) and gray (10YR 6/1); weak, medium, subangular blocky structure; firm, few roots; few fine tubular pores; common fine segregations and concretions of yellowish-brown (10YR 5/6) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

C3—56 to 70 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) silty clay; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6) and gray (10YR 6/1); massive; firm; few fine tubular pores; common fine segregations and concretions of yellowish-brown (10YR 5/6) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 40 inches. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2). It generally is silty clay loam or silty clay, but it is clay loam in places. The A horizon is 10 to 18 inches thick. Reaction in the A horizon is slightly acid or neutral. In places a very dark gray (10YR 3/1) A3 horizon is present.

The B2 horizon is dark grayish-brown (10YR 4/2 or 2.5Y 4/2), grayish-brown (10YR 5/2 or 2.5Y 5/2), olive brown (2.5Y 4/4), or light olive brown (2.5Y 5/4). It is silty clay or heavy silty clay loam. Reaction in the B2 horizon ranges from slightly acid to neutral.

The C horizon ranges from grayish brown (10YR 5/2 or 2.5Y 5/2) to yellowish brown (10YR 5/6). It is silty clay, heavy silty clay loam, or heavy clay loam above a depth of 40 inches. The C horizon is mildly alkaline or moderately alkaline.

Collinwood soils are associated with Waldorf soils, and they formed in similar parent material. They have a browner B horizon than that of Waldorf soils.

384—Collinwood silty clay loam, 0 to 2 percent slopes. This nearly level soil is on ground moraines on uplands. Areas of this soil are irregular in shape and generally range from 4 to 20 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are small areas of Waldorf and Nicollet soils.

Most areas of this soil are cultivated. The soil is well suited to row crops. In cultivated areas it has a slight limitation because of wetness. The clayey texture hinders the growth of roots and makes it difficult to maintain good tilth. The content of organic matter in the surface layer is high. Capability unit IIs-3; environmental planting group 2.

384B—Collinwood silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on uplands. Slopes are convex. Areas of this soil are irregular in shape and generally range from 4 to 16 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but in places the surface layer is a few inches thinner. Included in mapping are small areas of Clarion and Nicollet soils.

Most areas of this soil are cultivated. The soil is well suited to row crops. It is moderately susceptible to erosion, and the clayey texture hinders the growth of roots. The content of organic matter in the surface layer is moderate or

high. Capability unit IIe–4; environmental planting group 2.

384C—Collinwood silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on convex side slopes on uplands. Areas of this soil are long and narrow or irregular in shape and range from 4 to 16 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but in most places the surface layer is a few inches thinner. Included in mapping are small areas of Clarion soils and small areas of Collinwood soils that have slopes of more than 9 percent.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion, and the clayey texture hinders the growth of roots. The content of organic matter in the surface layer is moderate. Capability unit IIIe–1; environmental planting group 2.

Colo Series

The Colo series consists of poorly drained soils on bottom lands. These soils formed in silty alluvium, generally under a native vegetation of swamp grasses, sedges, and prairie grasses that tolerate wetness. Slopes range from 0 to 5 percent.

In a representative profile the surface layer is black silty clay loam about 48 inches thick. The underlying material is very dark gray silty clay loam.

Colo soils have moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high, and the content of available phosphorus generally is medium in both the surface layer and in the underlying material. The content of available potassium generally is medium in the surface layer and low or medium in the underlying material. Reaction is neutral or slightly acid in the surface layer.

The Colo soils are used mainly for cultivated crops, except for areas that are channeled. The major limitations in cultivated areas are wetness and occasional flooding.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a cultivated field 1,100 feet north and 190 feet east of the southwest corner of sec. 19, T. 90 N., R. 38 W.:

Ap—0 to 10 inches, black (N 2/0) silty clay loam; moderate, fine and medium, granular structure; friable; many roots; neutral, abrupt, smooth boundary.

A12—10 to 20 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure parting to weak, fine and medium, granular; friable; many roots; neutral; gradual, smooth boundary.

A13—20 to 28 inches, black (N 2/0) silty clay loam: weak, very fine and fine, subangular blocky structure; friable; common roots; neutral; gradual, smooth boundary.

A14—28 to 39 inches, black (N 2/0) silty clay loam; weak, medium, prismatic structure parting to weak, very fine and fine, subangular blocky; friable; few roots; few very fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

AC—39 to 48 inches, black (10YR 2/1) silty clay loam; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; few roots; few very fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

C1g—48 to 60 inches, very dark gray (10YR 3/1) silty clay loam; thin, discontinuous coatings of black (10YR 2/1 and N 2/0) on peds; massive; friable; common very fine segregations and concretions of iron and manganese oxides; neutral; gradual, wavy boundary.

C2g—60 to 72 inches, very dark gray (10YR 3/1) silty clay loam; thin, discontinuous coatings of black (10YR 2/1 and N 2/0) on peds; massive; friable; common, very fine segregations and concretions of iron and manganese oxides; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 36 to 56 inches. The A horizon is black (N 2/0 or 10YR 2/1) silty clay loam or heavy silt loam. It is 36 to 50 inches thick. Reaction in the A horizon is neutral or slightly acid. Some profiles have weak structural B horizons or AC horizons.

The C horizon ranges from very dark gray (10YR 3/1) to gray (5Y 5/1) or olive gray (5Y 5/2). It generally is silty clay loam. In places, however, it is clay loam, and in some places below a depth of 48 inches texture ranges from sandy loam to sand. Reaction in the C horizon ranges from neutral to moderately alkaline.

Colo soils, like the associated Calco and Afton soils, are poorly drained. Unlike Calco soils, Colo soils have a noncalcareous solum. Colo soils have a thicker A horizon than that of Afton soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands. Areas of this soil are long and narrow in shape and generally range from 20 to 80 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils that are covered by lighter colored overwash material as much as 16 inches thick and areas of soils that have a surface layer of clay loam. Also included are small areas of Calco soils and small areas of soils in which the lower part of the surface layer is mainly heavy silty clay loam or silty clay.

Where drainage is adequate and flooding is controlled, this soil is well suited to corn, soybeans, small grain, and alfalfa. Occassionally crops are damaged by overflow. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw–1; environmental planting group 2.

585B—Colo-Spillville complex, 2 to 5 percent slopes. This gently sloping complex is in narrow drainageways. Most areas are long and narrow and have a moderately deep stream channel. The silty, moderately fine textured Colo soil is in the central part of the areas, and the loamy, medium-textured Spillville soil is in the outer part.

About 60 percent of the mapped areas is Colo silty clay loam, and about 40 percent is Spillville loam. The individual areas range from 5 to 30 or more acres in size.

The Colo and Spillville soils have profiles similar to those described as representative of their respective series.

Included with this complex in mapping are a few areas of steeper Terril soils. Also included where this complex borders the moderately sloping Everly and Sac soils, are areas of Ely soils. Several inches of sediment have recently been deposited on the surface in places where the complex is adjacent to very steep Storden soils.

Many of the areas of this complex that are adjacent to moderately sloping and strongly sloping soils are cultivated. If drainage is adequate and flooding is controlled, the complex is well suited to crops in these areas. Many areas that are adjacent to moderately steep to very steep soils are used for permanent pasture. In places these pastured areas are almost inaccessible. Occasionally the crops on this complex are damaged by overflow from streams. In cultivated areas this complex has a moderate limitiation because of wetness in artificially drained areas and a severe limitation in areas that are not artificially drained. The narrow width of the mapped areas generally restricts the use of this complex to the same uses as those of soils on adjacent slopes. Capability unit IIw–1; environmental planting group 2.

C585—Colo-Spillville complex, channeled, 0 to 2 percent slopes. This nearly level complex is on the flood plains of meandering streams. It is characteristically dissected by many channels. Generally the Spillville soil is on the low

natural levees and the Colo soil is in the low-lying swales.

About 60 percent of the mapped areas is Colo silty clay loam, and about 40 percent is Spillville loam. The individual areas are long and somewhat narrow in shape and range from 20 to 500 or more acres in size.

The Colo and Spillville soils have profiles similar to those described as representative of their respective series, but the surface layer is not as thick and the underlying material is mildly alkaline or moderately alkaline.

Included with this complex in mapping are a few areas of soils that are calcareous in the lower part of the surface layer. Several inches of sediment have recently been deposited on the surface in places.

Most areas of this complex are in pasture or in trees or brush. Much of the area adjacent to the Little Sioux River is covered with scrub timber. This complex (fig. 12) is poorly suited to row crops. It is susceptible to frequent flooding. Capability unit Vw-1; environmental planting group 2.

Cylinder Series

The Cylinder series consists of somewhat poorly drained soils in glacial outwash areas and on stream terraces. These soils formed in loamy glacial outwash underlain by sand and gravel at a depth of 24 to 40 inches. The native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 20 inches thick. It is black loam in the upper part, very dark gray loam in the middle part, and very dark grayish-brown loam in the lower part. The subsoil extends to a depth of 30 inches. It is dark grayish-brown, friable loam in the upper part and dark grayish-brown, friable sandy clay loam in the lower part. The substratum is mixed olive-brown and grayish-brown sand and gravel to a depth of 56 inches and grayish-brown sand and gravel below.

Cylinder soils have moderate permeability above the sand and gravel and rapid or very rapid permeability within it. They have moderate or low available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil, and content of available potassium is low or medium in the surface layer and very low or low in the subsoil. Reaction generally is slightly acid or neutral in the surface layer.

Cylinder soils are used mainly for cultivated crops. The major limitation in cultivated areas is the limited available water capacity.

Representative profile of Cylinder loam, moderately deep, 0 to 2 percent slopes, in a cultivated field 500 feet north and 1,020 feet east of the southwest corner of NE1/4 sec. 34, T. 91 N., R. 37 W.:

Ap—0 to 9 inches, black (10YR 2/1) loams; weak, fine and medium, granular structure; friable; many roots; common very fine and fine tubular pores; common small pebbles; slightly acid; abrupt, smooth boundary.

A12—9 to 16 inches, very dark gray (10YR 3/1) loam; common fine peds of very dark grayish brown (10YR 3/2); discontinuous coatings of black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure parting to weak, fine and medium, granular; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A3—16 to 20 inches, very dark grayish-brown (2.5Y 3/2) loam; common fine peds of dark grayish brown (2.5Y 4/2); thin, discontinuous coatings of very dark gray (10YR 3/1) and black (10YR 2/1) on peds; weak, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B21—20 to 25 inches, dark grayish-brown (2.5Y 4/2) loam; thin, discontinous coatings of very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common small pebbles; neutral; clear, wavy boundary.

B22—25 to 30 inches, dark grayish-brown (2.5Y 4/2) sandy clay loam;

Figure 12.—**Scrub timber and brush clearly outline an area of Colo-Spillville complex, channeled, in the Little Sioux River bottom. The cropland in the foreground is on Colo and Spillville soils that are only occasionally flooded.**

common, fine and medium, faint mottles of light olive brown (2.5Y 5/4); thin, discontinuous coatings of very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; few roots; common fine and medium segregations and concretions of iron and manganese oxides; common small and medium pebbles; neutral; clear, wavy boundary.

IIC1—30 to 56 inches, mixed light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) sand and gravel; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6); single grained; loose; slight effervescence; moderately alkaline; gradual; wavy boundary.

IIC2—56 to 72 inches, grayish-brown (2.5Y 5/2) sand and gravel; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/4); single grained; loose; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 40 inches. The Al horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). The A3 horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (2.5Y 3/2). The A horizon is loam or light clay loam and is 14 to 24 inches thick. Reaction in the A horizon is slightly acid or neutral.

The B1 horizon, if present, is very dark grayish brown (2.5Y 3/2) or dark grayish brown (2.5Y 4/2). The B2 horizon generally ranges from dark grayish brown (2.5Y 4/2 or 10 YR 4/2) to grayish brown (2.5Y 5/2 or 10YR 5/2) and in most areas has mottles of olive brown and yellowish brown. Texture of the B1 and B2 horizons is loam or clay loam. Reaction in the B1 and B2 horizons is slightly acid or neutral. The B3 horizon, where present, generally consists of loamy glacial outwash material and sand and gravel. It ranges, however, from sandy loam and loamy sand to sand and gravel. The B horizon is 6 to 24 inches thick. Depth to sand or gravel ranges from 24 to 40 inches.

The IIC horizon generally ranges from sand to sand and gravel. In places the IIC1 horizon is loamy sand. Reaction in the upper 2 feet of the IIC horizon ranges from neutral to moderately alkaline. In many places it is neutral to a depth of 50 inches.

Cylinder soils are associated with Wadena and Biscay soils and are intermediate in drainage between those two series. They have a thicker A horizon and a grayer B horizon than those of Wadena soils. They lack the gray B horizon that is characteristic of Biscay soils. Cylinder soils have drainage similar to that of Nicollet soils. Unlike Nicollet soils, they have sand and gravel at a depth of 24 to 40 inches.

203—Cylinder loam, deep, 0 to 2 percent slopes. This nearly level soil is in glacial outwash areas and on stream terraces. It has sand and gravel at a depth of 32 to 40 inches. Areas of this soil are irregular in shape and generally range from 4 to 20 acres in size.

This soil has a profile similar to the one described as representative of the series, but sand and gravel are deeper. Included in mapping are areas of soils in which depth to sand and gravel is less than 32 inches, and areas of soils in which that depth is more than 40 inches. Also included are some areas of a similar soil that are calcareous throughout.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, small grain, and alfalfa. In cultivated areas it has a slight limitation because of wetness in wet years and does not have enough water available for maximum yields in dry years. Capability unit I–2; environmental planting group 1.

202—Cylinder loam, moderately deep, 0 to 2 percent slopes. This nearly level soil is in glacial outwash areas and on stream terraces. It has sand and gravel at a depth of 24 to 32 inches. Areas of this soil are irregular in shape and generally range from 4 to 50 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils in which depth to sand and gravel is more than 32 inches and areas of soils that are calcareous throughout.

Most areas of this soil are cultivated. The soil is well suited to crops. In many years, however, it does not have enough water available for maximum yields of crops. Capability unit IIs–2; environmental planting group 1.

Dickinson Series

The Dickinson series consists of somewhat excessively drained soils on uplands and on stream terraces. These soils formed in moderately coarse textured and coarse textured glacial drift or outwash and alluvial sediment reworked or redeposited by the wind. The native vegetation was prairie grasses. Slopes range from 2 to 5 percent.

In a representative profile the surface layer is about 13 inches thick. It is very dark brown fine sandy loam in the upper part and mixed very dark grayish-brown and dark-brown fine sandy loam in the lower part. The subsoil extends to a depth of 39 inches. It is brown, very friable fine sandy loam in the upper part, dark yellowish-brown, very friable loamy fine sand in the middle part, and brown, very friable loamy fine sand in the lower part. The substratum is yellowish-brown fine sand to a depth of 56 inches and mixed grayish-brown and brown sand below.

Dickinson soils have moderately rapid permeability and low available water capacity. The content of organic matter in the surface layer is moderate. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and very low in the subsoil. Unless these soils are limed, reaction generally is medium acid or slightly acid in the surface layer.

Dickinson soils are used mainly for cultivated crops and pasture. The major limitations in cultivated areas are low available water capacity and erosion.

Representative profile of Dickinson fine sandy loam, 2 to 5 percent slopes, in a cultivated field 550 feet north and 36 feet east of the southwest corner of NW1/4 sec. 7, T. 91 N., R. 35 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) fine sandy loam; weak, fine, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

A3—8 to 13 inches, mixed very dark grayish-brown (10YR 3/2) and drak brown (10YR 3/3 and 10YR 4/3) fine sandy loam; thin, discontinuous coatings of very dark brown (10YR 2/2) on peds, very dark grayish brown (10YR 3/2) when kneaded; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; neutral; clear, smooth boundary.

B2—13 to 25 inches, brown (10YR 4/3) fine sandy loam; thin, discontinous coatings of dark brown (10YR 3/3) on peds; weak, fine and medium, subangular blocky structure; very friable; common roots; common fine tubular pores; slightly acid; gradual, smooth boundary.

B31—25 to 31 inches, dark yellowish-brown (10YR 4/4) loamy fine sand; weak, fine and medium, subangular blocky structure; very friable; common roots; common fine tubular pores; slightly acid; gradual, smooth boundary.

B32—31 to 39 inches, brown (10YR 4/3) loamy fine sand; weak, fine and medium, subangular blocky structure; very friable; few roots; few fine tubular pores; slightly acid; gradual, smooth boundary.

C1—39 to 56 inches, yellowish-brown (10YR 5/4) fine sand; very weak, medium, subangular blocky structure; very friable; few roots; few fine tubular pores; neutral; gradual wavy boundary.

C2—56 to 72 inches, mixed grayish-brown (10YR 5/2) and brown (10YR 5/2) and brown (10YR 5/3) sand; single grained; loose; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 50 inches. Depth to loamy sand and sand generally is 24 to 36 inches, but it ranges from 20 to 42 inches. The A1 or Ap horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Reaction in the A1 horizon ranges from medium acid to neutral. The A horizon is fine sandy loam, sandy loam, or light loam, and is 10 to 20 inches thick.

The B2 horizon ranges from very dark grayish brown (10YR 3/2) to brown (10YR 4/3) in the upper part and from brown (10YR 4/3) to yellowish brown (10YR 5/6) in the lower part. It ranges from fine sandy loam to loamy sand. Reaction in the B2 horizon is slightly acid or medium acid.

The C1 horizon ranges from dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6). It is loamy fine sand, loamy sand, fine sand, or sand. Reaction in the C1 horizon is slightly acid or neutral.

Dickinson soils are associated with Clarion and Estherville soils. They contain more sand than Clarion soils. Dickinson soils have a thicker solum than Estherville soils. Unlike Estherville soils, they have no gravel and coarse sand in the C1 horizon.

175B—Dickinson fine sandy loam, 2 to 5 percent slopes. This gently sloping soil is on sandy convex ridges on glacial till uplands and on stream terraces. Areas of this soil are irregular in shape and range from 4 to 10 or more acres in size.

Included with this soil in mapping are areas of soils that contain coarse sand and gravel. Also included are small areas of Dickinson soils that have slopes of less than 2 percent.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is susceptible to erosion and has low available water capacity. The content of organic matter in the surface layer is moderate. Capability unit IIIe-4; environmental planting group 1.

Ely Series

The Ely series consists of somewhat poorly drained soils that generally are on low concave foot slopes at the base of upland slopes. These soils formed in silty colluvium and local alluvium under a native vegetation of prairie grasses. Slopes range from 2 to 5 percent.

In a representative profile the surface layer is about 29 inches thick. It is black silty clay loam in the upper part and very dark brown silty clay loam in the lower part. The subsoil extends to a depth of 52 inches. It is friable silty clay loam and is very dark grayish brown, dark grayish brown, olive brown, grayish brown, and yellowish brown. The substratum is grayish-brown silt loam.

Ely soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction generally is slightly acid in the surface layer.

Ely soils are used mainly for crops. These soils have a slight wetness limitation in wet years.

Representative profile of Ely silty clay loam, 2 to 5 percent slopes, in a cultivated field 360 feet north and 230 feet east of the southwest corner of NW1/4 sec. 29, T. 90 N., R. 38 W.:

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; moderate, fine, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) silty clay loam; weak, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; many roots; common very fine and fine tubular pores; slightly acid; gradual, smooth boundary.

A13—15 to 24 inches, very dark brown (10YR 2/2) silty clay loam; black (10YR 2/1) coatings on peds; moderate, very fine and fine, subangular blocky structure; friable; many roots; common very fine and fine tubular pores; slightly acid; gradual, smooth boundary.

A14—24 to 29 inches, very dark brown (10YR 2/2) silty clay loam; black (10YR 2/1) coatings on peds; weak, fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; very few fine segregations of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B1—29 to 33 inches, very dark grayish-brown (10YR 3/2) silty clay loam; black (10YR 2/1) and very dark brown (10YR 2/2) coatings on peds; weak, fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few fine segregations of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B21—33 to 38 inches, dark grayish-brown (10YR 4/2) silty clay loam; common, medium, faint mottles of brown (10YR 4/3); thin, discontinuous coatings of very dark grayish brown (10YR 3/2) and black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

B22—38 to 43 inches, olive-brown (2.5Y 4/3) silty clay loam; coatings of dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) on peds; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; few roots common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

B3—43 to 52 inches, mixed grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/4 and 10YR 5/6) silty clay loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky; friable; few roots; common very fine and fine tubular pores; many fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

C1—52 to 77 inches, grayish-brown (2.5Y 5/2) silt loam; common, medium, distinct mottles of yellowish brown (10YR 5/4 and 10YR 5/6); massive; friable; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; mildly alkaline; gradual, smooth boundary.

C2—77 to 94 inches, grayish-brown (2.5Y 5/2) silt loam; common, medium, distinct mottles of yellowish brown (10YR 5/4 and 10YR 5/6); massive; friable; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 40 to 62 inches. The A horizon is black (10YR 2/1) to very dark brown (10YR 3/2) and is 24 to 32 inches thick. Reaction in the A horizon generally is slightly acid or medium acid.

The B1 horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). The B2 horizon is dark grayish brown (10YR 4/2) or 2.5Y 4/2), grayish brown (10YR 5/2 or 2.5Y 5/2), or olive brown (2.5Y 5/3). The B3 horizon ranges from grayish brown (10YR 5/2 or 2.5Y 5/2) to olive brown (2.5Y 4/3) to yellowish brown (10YR 5/6). The B horizon is 16 to 36 inches thick. Reaction in the B horizon is slightly acid or neutral.

The C horizon has the same range in color as that of the B3 horizon. It is silt loam or silty clay loam. Reaction in the C horizon ranges from neutral to moderately alkaline.

Ely soils are associated with Primghar, Afton, and Colo soils. They have a thinner A horizon than the one in Colo soils and a thicker A horizon than the one in Primghar soils. They are not so wet as Colo and Afton soils and not so gray in the B horizon as Afton soils.

428B—Ely silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on low, concave foot slopes. Areas of this soil generally are long and narrow in shape and 4 to 20 acres in size.

Included with this soil in mapping are small areas of Afton and Primghar soils. Also included are small areas of Ely soils that have slopes of less than 2 percent.

This soil is well suited to corn, soybeans, small grain, and alfalfa. It is subject to runoff from adjacent slopes and is moderately susceptible to erosion. Capability unit IIe-2; environmental planting group 1.

Estherville Series

The Estherville series consists of somewhat excessively drained soils on broad glacial outwash plains and stream benches and on kames in glacial moraines. These soils formed in loamy glacial deposits underlain by sand and gravel generally at a depth of 15 to 24 inches. The native vegetation was prairie grasses. Slopes range from 2 to 9 percent.

In a representative profile the surface layer is black sandy loam about 13 inches thick. The subsoil of very friable sandy loam extends to a depth of 19 inches. It is very dark grayish brown in the upper part and dark brown in the lower part. The substratum is dark yellowish-brown gravelly sand to a depth of 22 inches and yellowish-brown gravelly sand below.

Estherville soils have moderately rapid permeability in the loamy upper part and rapid or very rapid permeability in the underlying sand and gravel. They have very low or low available water capacity. The content of organic matter in the surface layer ranges from moderately low or very low. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium is very low or low in the subsoil. The content of available potassium is very low or low in the surface layer and very low in the subsoil. Unless these soils are limed, reaction generally is medium acid or slightly acid in the surface layer.

Estherville soils are used mainly for permanent pasture and cultivated crops. The major limitations in cultivated areas are very low or low available water capacity and erosion.

Representative profile of Estherville sandy loam, 2 to 5 percent slopes, in a cultivated field 504 feet south and 810 feet east of the northwest corner of NE1/4 sec. 19, T. 90 N., R. 36 W.:

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; moderate, fine, granular structure; very friable; common roots; neutral; abrupt, smooth boundary.

A12—8 to 13 inches, black (10YR 2/1) sandy loam; common peds of dark brown (10YR 3/3); weak, fine and medium, subangular blocky structure; very friable; common roots; few fine tubular pores; neutral; gradual, smooth boundary.

B1—13 to 15 inches, very dark grayish-brown (10YR 3/2) sandy loam; common peds of dark brown (10YR 3/3) and brown (10YR 4/3); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure; very friable; common roots; few fine tubular pores; neutral; gradual, smooth boundary.

B2—15 to 19 inches, dark-brown (10YR 3/3) sandy loam; common, fine, faint mottles of brown (10YR 4/3); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure; very friable; common roots; few fine tubular pores; neutral; clear, wavy boundary.

IIC1—19 to 22 inches, dark yellowish-brown (10YR 4/4) gravelly sand; single grained; loose; few roots; slight effervescence; mildly alkaline; clear, smooth boundary.

IIC2—22 to 32 inches, yellowish-brown (10YR 5/4) gravelly sand; single grained; loose; slight effervescence; moderately alkaline; clear, smooth boundary.

IIC3—32 to 58 inches, yellowish-brown (10YR 5/4) gravelly sand; single grained; loose; slight effervescence; moderately alkaline; clear, smooth boundary.

IIC4—58 to 72 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) gravelly sand; single grained; loose; slight effervescence; moderately alkaline.

Thickness of the solum generally is 15 to 24 inches. In places, however, it ranges to 30 inches. The A1 horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). The A horizon is 9 to 18 inches thick. Reaction in the A horizon ranges from medium acid to neutral.

The B2 horizon ranges from dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4) loam to coarse sandy loam. Reaction ranges from medium acid to neutral.

The IIC horizon ranges from grayish brown (10YR 5/2) to yellowish brown (10YR 5/6). The material ranges from coarse sand that has some gravel to sand and gravel. Reaction in the IIC horizon generally is mildly alkaline or moderately alkaline.

Estherville soils are associated with Salida and Wadena soils, and they have a somewhat similar profile. They generally have a thicker solum than that of Salida soils, and they are more acid below the A horizon than those soils. They have a thinner solum than that of Wadena soils, and they have less clay in the A and B2 horizons than those soils.

34B—Estherville sandy loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridges in glacial outwash areas, on stream terraces, and on small kames or knobs on glacial till uplands. Areas of this soil are irregular in shape and range from 4 to 10 acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of Salida soils and areas of soils that have a surface layer of loam.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to both water erosion and soil blowing. The soil has low or very low available water capacity and does not have enough water available for satisfactory growth of crops in some years. The content of organic matter in the surface layer is moderately low or low. Capability unit IIIe-4; environmental planting group 4.

34C2—Estherville sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex ridges and slopes in glacial outwash areas, on stream terraces, and on small kames or knobs on glacial till uplands. Areas of this soil are long and narrow or irregular in shape and range from 4 to 10 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. Included in mapping are small areas of Salida soils.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to both water erosion and soil blowing. The soil has low or very low available water capacity and does not have enough water available for satisfactory growth of crops in some years. The content of organic matter in the surface layer is low or very low. Capability unit IIIe-4; environmental planting group 4.

Everly Series

The Everly series consists of well-drained soils on uplands. These soils formed in loamy material that is about 20 to 30 inches thick and in the underlying Wisconsin (Tazewell) glacial till. The native vegetation was prairie grasses. Slopes are convex and range from 2 to 9 percent.

In a representative profile the surface layer is about 13 inches thick. It is very dark brown clay loam in the upper part and very dark grayish-brown clay loam in the lower part. The subsoil extends to a depth of 31 inches. It is brown, friable clay loam in the upper part and brown, friable loam in the lower part. The substratum is yellowish-brown loam.

Everly soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer ranges from moderately low to high. The content of available phosphorus generally is low in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction is slightly acid or medium acid in the surface layer.

Everly soils are used mainly for cultivated crops. The major limitation in cultivated areas is erosion.

Representative profile of Everly clay loam, 2 to 5 percent slopes, in a cultivated field 168 feet north and 162 feet east of the southwest corner of SE1/4 sec. 2, T. 93 N., R. 38 W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) clay loam; moderate, fine, granular structure; friable; common roots; slightly acid; abrupt, smooth boundary.

A3—9 to 13 inches, very dark grayish-brown (10YR 3/2) clay loam; common, fine, faint mottles of dark brown (10YR 3/3) and brown (10YR 4/3); very dark brown (10YR 2/2) coatings on peds; weak, medium, subangular blocky structure parting to moderate, fine granular; friable; common roots; few very fine and fine tubular pores; slightly acid; clear, smooth boundary.

B21—13 to 17 inches, brown (10YR 4/3) clay loam; common, discontinuous coatings of dark brown (10YR 3/3) on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B22—17 to 22 inches, brown (10YR 4/3) clay loam; few, discontinuous coatings of dark brown (10YR 3/3) on peds; weak, medium, prismatic structure parting to weak, subangular blocky; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B23—22 to 27 inches, brown (10YR 4/3) clay loam; thin, discontinuous dark-brown (10YR 3/3) coatings on peds; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; common roots; common very fine and fine tubular pores; neutral; abrupt, wavy boundary.

IIB3—27 to 31 inches, brown (10YR 4/3) heavy loam; weak, medium, prismatic structure parting to weak, fine and medium, subangular blocky; friable; common roots; common very fine and fine tubular pores; few fine and medium concretions of yellowish-brown (10YR 5/6) iron and manganese oxides; common fine and medium concretions of calcium carbonate; many small pebbles; slight effervescence; mildly alkaline; clear, wavy boundary.

IIC1—31 to 38 inches, yellowish-brown (10YR 5/4) loam; common, fine and medium, distinct and faint mottles of light brownish gray (10YR 6/2), strong brown (7.5YR 5/6), and yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; friable; few roots; common fine and medium concretions of strong-brown (7.5YR 5/6) and very dark brown (10YR 2/2) iron and manganese oxides; common fine and medium concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC2—38 to 60 inches, yellowish-brown (10YR 5/6) loam; common, fine and medium, distinct and faint mottles of light brownish gray (10YR 6/2), strong brown (7.5YR 5/6), and yellowish brown (10YR 5/4); massive; friable; few fine tubular pores; common fine and medium concretions of strong-brown (7.5YR 5/6) and very dark brown (10YR 2/2) iron and manganese oxides; common fine and medium concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 42 inches. Depth to glacial till ranges from 18 to 36 inches. The solum generally extends a few inches into the glacial till.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It is clay loam or heavy loam that is high in silt, or silty clay loam that is high in sand. Unless eroded, the A horizon is 10 to 16 inches thick. Reaction in the A horizon generally is slightly acid or medium acid.

The B2 horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4). It is clay loam or heavy loam. Reaction in the B2 horizon is slightly acid or neutral, and reaction in the B3 horizon ranges from neutral to moderately alkaline.

The IIC horizon ranges from dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6). It has few to common brownish-gray (10YR 6/2) to strong-brown (7.5Y 5/6) mottles. The IIC horizon is loam or clay loam. Reaction in the C horizon is mildly alkaline or moderately alkaline.

Everly soils are associated with Sac soils, and they have a somewhat similar profile. Everly soils have more sand in the A and B horizons than Sac soils, and depth to glacial till generally is a few inches less in Everly soils than it is in Sac soils.

577B—Everly clay loam, 2 to 5 percent slopes. This gently sloping soil is on uplands. Slopes are convex. Areas of this soil generally are long and narrow in shape and 4 to 30 acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils in which depth to glacial till is less than 18 inches. Also included are areas of Storden and Sac soils.

Most areas of this soil are cultivated. Where erosion is controlled, the soil is well suited to row crops. It is moderately susceptible to erosion. The content or organic matter in the surface layer is moderate or high. Capability unit IIe–1; environmental planting group 1.

577C—Everly clay loam, 5 to 9 percent slopes. This moderately sloping soil is on convex side slopes. Areas of this soil are long and narrow in shape and range from 4 to 12 acres in size.

This soil has a profile similar to the one described as representative of the series, but depth to glacial till generally is a few inches less. Included in mapping are areas of soils in which depth to glacial till is less than 18 inches. Also included are areas of Storden soils.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderate. Capability unit IIIe–1; environmental planting group 1.

577C2—Everly clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex side slopes. Areas of this soil are long and narrow in shape and range from 4 to 40 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner and depth to glacial till generally is a few inches less. Included in mapping are areas of soils in which depth to glacial till is less than 18 inches. Also included are areas of Storden soils.

Most areas of this soil are used for cultivated crops. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–1; environmental planting group 1.

Fill Land

504—Fill land. This mapping unit consists of medium-textured and moderately fine textured material dredged from the bottom of Storm Lake. Individual areas are irregular in shape and range from 4 to 20 or more acres in size.

Most Fill land areas are used for public parks and have areas for boating, camping, fishing, picnicking, and swimming. These areas were not intended for farming. This Fill land has a very severe limitation because of wetness and is poorly suited to row crops. Capability unit Vw–2; environmental planting group 2.

Galva Series

The Galva series consists of well-drained soils on loess-covered uplands and on loess-covered stream terraces. These soils formed in this loess under a native vegetation of tall prairie grasses. Slopes are convex and range from 0 to 9 percent.

In a representative profile the surface layer is about 16 inches thick. It is very dark brown silty clay loam in the upper part and very dark grayish-brown silty clay loam in the lower part. The subsoil extends to a depth of 48 inches. It is dark-brown, friable silty clay loam in the upper part; brown, friable silty clay loam in the middle part; and brown, friable silt loam in the lower part. The substratum is yellowish-brown clay loam that has mottles of grayish brown.

Galva soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from high to moderately low. The content of available phosphorus is very low or low in the

surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and low in the subsoil. Unless these soils are limed, reaction generally is acid in the surface layer.

Galva soils are used mainly for cultivated crops. The major limitation in cultivated areas is erosion.

Representative profile of Galva silty clay loam, 2 to 5 percent slopes, in a cultivated field 144 feet north and 144 feet west of the southeast corner of sec. 27, T. 90 N., R. 38 W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) silty clay loam; moderate, fine and medium, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A12—9 to 13 inches, very dark brown (10YR 2/2) silty clay loam; few fine peds of very dark grayish brown (10YR 3/2); weak, fine, subangular blocky structure parting to moderate, fine and medium, granular; friable; common roots; few very fine and fine tubular pores; slightly acid; gradual, smooth boundary.

A3—13 to 16 inches, very dark grayish-brown (10YR 3/2) silty clay loam; few fine peds of dark brown (10YR 3/3); thin, discontinuous coatings of very dark brown (10YR 2/2) on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; few very fine and fine tubular pores; slightly acid; gradual, smooth boundary.

B21—16 to 20 inches, dark-brown (10YR 3/3) silty clay loam; few peds of brown (10YR 4/3); thin, discontinuous coatings of very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B22—20 to 28 inches, brown (10YR 4/3) silty clay loam; thin, discontinuous, dark brown (10YR 3/3) coatings on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B23—28 to 36 inches, brown (10YR 4/3) silty clay loam; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B31—36 to 42 inches, brown (10YR 4/3) silty clay loam; few, fine, faint mottles of grayish brown (2.5Y 5/2); weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B32—42 to 48 inches, brown (10YR 4/3) heavy silt loam; common, fine, faint mottles of grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6); weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; abrupt, wavy boundary.

IIC1—48 to 60 inches, yellowish-brown (10YR 5/4) clay loam; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2); massive; firm; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC2—60 to 69 inches, yellowish-brown (10YR 5/4) clay loam; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6), grayish brown 2.5Y 5/2), and light brownish gray (2.5Y 6/2), massive; firm; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC3—69 to 88 inches, yellowish-brown (10YR 5/4) clay loam; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6), grayish brown (2.5Y 5/2), light brownish gray (2.5Y 6/2), and strong brown (7.5YR 5/6); massive; firm; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum generally ranges from 36 to 48 inches. Depth to glacial till generally ranges from 40 to 60 inches. The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). Unless eroded, the A horizon is 10 to 16 inches thick. Reaction in the A horizon generally is slightly acid or medium acid.

The B2 horizon is dark brown (10YR 3/3) or brown (10YR 4/3 or 10YR 5/3). Reaction is slightly acid or neutral.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/4). Texture is light silty clay loam, silt loam, or clay loam. Reaction in the C horizon is moderately alkaline or mildly alkaline.

Galva soils are associated with Sac and Primghar soils. Unlike Sac soils, which formed in loess and the underlying glacial till, Galva soils formed entirely in loess. Galva soils have a browner B horizon and a slightly thinner A horizon than those of Primghar soils.

310—Galva silty clay loam, 0 to 2 percent slopes. This nearly level soil is on uplands. Slopes are convex. Areas of this soil are irregular in shape and range from 4 to 12 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is darker and the lower part of the subsoil has more grayish-brown mottles. Included in mapping are small areas of Primghar soils.

Most areas of this soil are used for cultivated crops. The soil is well suited to row crops. The content of organic matter in the surface layer is high. Capability unit I–1; environmental planting group 1.

310B—Galva silty clay loam, 2 to 5 percent slopes. This soil is on uplands. Slopes are convex. Areas are irregular in shape and generally range from 10 to 100 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils in which depth to glacial till is less than 40 inches. Also included are areas in the northwestern part of the county in which the surface layer has some gray, grainy coats and the subsoil contains more clay than the representative profile. In these places the soils reflect the presence of some trees that grow on them.

Most areas of this soil are used for cultivated crops. Where erosion is controlled, the soil is well suited to corn, soybeans, small grain, and alfalfa. It is moderately susceptible to erosion. The content of organic matter in the surface layer is moderate or high. Capability unit IIe–1; environmental planting group 1.

310C2—Galva silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex side slopes on loess-covered uplands. Areas of this soil are long and narrow in shape and range from 4 to 16 acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is a few inches thinner. Included in mapping are small areas of Sac soils.

Most areas of this soil are used for cultivated crops. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–1; environmental planting group 1.

T310—Galva silty clay loam, benches, 1 to 3 percent slopes. This nearly level soil is on loess-covered stream terraces. Slopes are convex. Areas generally are oblong or irregular in shape and range from 4 to 16 acres in size.

This soil has a profile similar to the one described as representative of the series, but the substratum is generally sand and gravel. Included in mapping are small areas of soils in which depth to sand and gravel is less than 40 inches. Also included are small areas of soils that have slopes of more than 3 percent.

Most areas of this soil are used for cultivated crops. The soil is well suited to row crops. The content of organic

matter in the surface layer is high. Capability unit I–1; environmental planting group 1.

Gravel Pits

501—Gravel pits. This mapping unit consists of excavated areas on stream terraces and in glacial outwash areas that have or have had substantial deposits of sand and gravel. Individual areas are irregular in shape and range from 2 to 40 acres in size.

Many gravel pits are active and supply the sand and gravel needs of the county. Others have been abandoned either because all the sand and gravel has been excavated or because the remaining deposits of sand and gravel contain too many fine particles. Most of the abandoned gravel pits have been left open, and many are used as dumps for old farm machinery. In the low-lying areas many of the active gravel pits have water in the excavations. Many ponds in the county are abandoned gravel pits. A few of these are used for public parks and have areas for fishing, picnicking, and swimming. All these gravel pit areas are poorly suited to row crops. Capability unit VIIs–1; environmental planting group 4.

Harps Series

The Harps series consists of highly calcareous, poorly drained soils on till plains or outwash plains, generally on narrow rims of depressions. These soils formed in glacial till or glacial sediment under a native vegetation of swamp grasses, sedges, and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is black loam about 16 inches thick. The subsoil of friable loam extends to a depth of 35 inches. It is mixed dark gray and olive gray in the upper part, olive gray in the middle part, and light olive gray in the lower part. The substratum of loam is mixed olive gray and light olive gray to a depth of 50 inches, and light olive gray below.

Harps soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus and available potassium are both very low in the surface layer and in the subsoil. Reaction is moderately alkaline in the surface layer.

Harps soils are used mainly for cultivated crops. The major limitations in cultivated areas are wetness and low fertility.

Representative profile of Harps loam, 0 to 2 percent slopes, in a cultivated field 460 feet north and 120 feet west of the southeast corner of sec. 32, T. 93 N., R. 37 W.:

Apca—0 to 9 inches, black (10YR 2/1) loam; moderate, fine and medium, granular structure; friable; many roots; few snail shells and fine segregations of calcium carbonate; violent effervescence; moderately alkaline; abrupt, smooth boundary.

A12ca—9 to 16 inches, black (10YR 2/1) loam, gray (10YR 5/1) when dry; moderate, very fine and fine, granular structure; friable; many roots; common very fine tubular pores; common fine segregations of calcium carbonate; common fine fragments of snail shells; violent effervescence; moderately alkaline; gradual, smooth boundary.

B1gca—16 to 23 inches, mixed dark-gray (5Y 4/1) and olive-gray (5Y 5/2) loam, light gray (5Y 6/1 to 5Y 7/1) when dry; thin, discontinuous coatings of black (10YR 2/1) and very dark gray (10YR 3/1) on peds; weak fine, subangular blocky structure; friable; common roots; few fine tubular pores; common fine and medium segregations and concretions of calcium carbonate; violent effervescence; moderately alkaline; gradual, smooth boundary.

B2gca—23 to 29 inches, olive-gray (5Y 5/2) loam, light olive gray (5Y 6/2) to light gray (5Y 7/2) when dry; common, fine and medium, faint mottles of dark gray (5Y 4/1) and light olive gray (5Y 6/2); weak, fine and medium, subangular blocky structure; friable; common roots; few fine tubular pores; few fine segregations of iron and manganese oxides; fine and medium segregations and concretions of calcium carbonate; violent effervescence; moderately alkaline; gradual, smooth boundary.

B3gca—29 to 35 inches, light olive-gray (5Y 6/2) loam; common, fine, faint mottles of pale olive (5Y 6/3); weak, medium, subangular blocky structure; friable; few roots; few fine tubular pores; few fine segregations of yellowish-brown (10YR 5/6 and 10YR 5/8), strong-brown (7.5YR 5/6), and very dark brown (10YR 2/2) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; violent effervescence; moderately alkaline; gradual, smooth boundary.

C1g—35 to 50 inches, mixed olive-gray (5Y 5/2) and light olive-gray (5Y 6/2) loam; common, fine, distinct mottles of pale olive (5Y 6/3); strong-brown (7.5Y 5/8) and very dark brown (10YR 2/2) iron and manganese oxides; massive; friable; common fine and medium concretions of calcium carbonate; violent effervescence; moderately alkaline; gradual, smooth boundary.

C2g—50 to 72 inches, light olive-gray (5Y 6/2) loam; common, fine and medium, faint and distinct mottles of gray (5Y 6/1), olive gray (5Y 5/2), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6); massive; friable; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 30 to 50 inches. The A1 or Ap horizon is black (10YR 2/1) or very dark gray (10YR 3/1). The A horizon is loam or light clay loam. The A1 horizon or the combined A1 and Ap horizons have a total thickness of 10 to 16 inches.

The B2 horizon ranges from gray (5Y 5/1 or 5Y 6/1) to grayish brown (2.5Y 5/2) or light brownish gray (2.5Y 6/2). The B horizon is loam, light clay loam, or sandy clay loam and is 14 to 36 inches thick. The C horizon has a range in color similar to that of the B2 horizon.

Harps soils, like the associated Canisteo soils, are calcareous. They have less clay in the solum and are more calcareous in the A horizon than those soils.

95—Harps loam, 0 to 2 percent slopes. This nearly level, highly calcareous soil is on narrow rims of depressions. Areas of this soil generally are long and narrow in shape and generally range from 2 to 20 or more acres in size.

Included with this soil in mapping are small areas of Canisteo and Okoboji soils.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to row crops. It has a seasonal high water table and low fertility. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw-4; environmental planting group 2.

Lanyon Series

The Lanyon series consists of calcareous, very poorly drained soils in shallow glacial lake basins. These soils formed in water-worked glacial sediment or local alluvium under a native vegetation of swamp grasses and sedges. Slopes range from 0 to 1 percent.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil extends to a depth of 21 inches. It is olive-gray, firm silty clay. The substratum is mixed gray and olive-gray silty clay loam.

Lanyon soils have slow permeability and high available water capacity. The content of organic matter in the surface

layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium ranges from very low to low in the surface layer and in the subsoil. Reaction is moderately alkaline in the surface layer.

Lanyon soils are used mainly for cultivated crops. The major limitations in cultivated areas are wetness and ponding.

Representative profile of Lanyon silty clay loam, 0 to 1 percent slopes, in a cultivated field 185 feet south and 130 feet east of the northwest corner of SW1/4 sec. 29, T. 93 N., R. 36 W.:

Ap—0 to 7 inches, black (N 2/0) silty clay loam; moderate, fine, granular structure; friable; many roots; common fine fragments of snail shells; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A3—7 to 13 inches, black (N 2/0) heavy silty clay loam; common, fine and medium, distinct mottles of gray (5Y 6/1); weak, fine, subangular blocky structure parting to moderate, fine, granular; firm; common roots; common fine fragments of snail shells; slight effervescence; moderately alkaline; abrupt, wavy boundary.

B2g—13 to 21 inches, olive-gray (5Y 5/2) silty clay; common, fine and medium, faint and distinct mottles of gray (5Y 5/1) and olive (5Y 5/4); weak, medium, prismatic structure parting to weak, fine, subangular blocky; firm, fine tubular pores; common fine root channels filled with black (N 2/0) and very dark gray (5Y 3/1) silty clay loam; common fine segregations of iron and manganese oxides; strong effervescence; moderately alkaline; gradual, smooth boundary.

C1g—21 to 35 inches, mixed gray (5Y 5/1) and olive-gray (5Y 5/2) heavy silty clay loam; common, fine and medium, distinct mottles of light olive brown (2.5Y 5/4); weak, medium, prismatic structure; firm; common fine tubular pores; few fine root channels filled with very dark gray (5Y 3/1) silty clay loam; common fine segregations of iron and manganese oxides; common fine segregations of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2g—35 to 60 inches, mixed gray (5Y 5/1) and olive-gray (5Y 5/2) silty clay loam; common, fine and medium, distinct mottles of light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/6); massive; friable; common fine tubular pores; common fine and medium segregations of iron and manganese oxides; common fine segregations of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 10 to 24 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). The A horizon is 8 to 16 inches thick. Reaction in the A horizon is mildly alkaline or moderately alkaline. This horizon is calcareous, and because of this is not within the defined range for the series. This difference, however, does not significantly affect the use and behavior of the soils.

The Bg horizon, if present, ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2). It is heavy silty clay loam or silty clay.

The Cg horizon ranges from gray (5Y 5/1) to light olive gray (5Y 6/2). It is silty clay loam or silty clay.

Lanyon soils have drainage similar to Blue Earth, Okoboji, and Wacousta soils. They have a thinner A horizon than the A horizon in Blue Earth and Okoboji soils. Unlike Okoboji and Wacousta soils, Lanyon soils have a calcareous solum. They have lower content of organic matter in the A horizon than Blue Earth soils. Lanyon soils contain more clay than Blue Earth and Wacousta soils.

606—Lanyon silty clay loam, 0 to 1 percent slopes. This depressional soil is in shallow glacial lake basins. Areas of this soil are irregular in shape. One area is more than 500 acres in size and makes up most of the acreage in the county.

Included with this soil in mapping are small areas of soils that have a surface layer more than 16 inches thick.

Most areas of this soil are cultivated. The soil is moderately well suited to row crops. It is highly susceptible to ponding on the surface and generally has a very high water table. In cultivated areas it has a severe limitation because of wetness. Capability unit IIIw-2; environmental planting group 2.

Lester Series

The Lester series consists of well-drained soils on convex side slopes, generally in wooded areas. These soils formed in glacial till under a native vegetation of grasses and trees. Slopes range from 18 to 40 percent.

In a representative profile the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is very dark grayish-brown loam about 2 inches thick. The subsoil extends to a depth of 31 inches. It is brown, friable to firm clay loam. The substratum is mixed yellowish-brown and grayish-brown clay loam to a depth of 40 inches and mixed light brownish-gray and yellowish-brown loam below.

Lester soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is low. The content of available phosphorus generally is very low or low in the surface layer and low or medium in the subsoil. The content of available potassium is low or medium in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction is medium and or slightly acid in the surface layer.

Lester soils are used mainly for woodland and woodland pasture. The major limitations for other land uses are steep or very steep slopes and a severe hazard of erosion.

Representative profile of Lester loam, 25 to 40 percent slopes, in a wooded area 400 feet south and 30 feet east of the northwest corner of sec. 23, T. 93 N., R. 38 W.:

A1—0 to 7 inches, very dark gray (10YR 3/1) loam; moderate, medium and coarse, granular structure; friable; many roots; few fine tubular pores; common small pebbles; medium acid; clear, smooth boundary.

A2—7 to 9 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, platy structure; friable; common roots; common fine tubular pores; common small pebbles; medium acid; clear, wavy boundary.

B1t—9 to 13 inches, brown (10YR 4/3) clay loam; thick, continuous coatings of very dark grayish brown (10YR 3/2) on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; thin, discontinuous clay films of very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2); common small pebbles; medium acid; gradual, smooth boundary.

B21t—13 to 20 inches, brown (10YR 4/3) clay loam; thin, discontinuous coatings of very dark grayish brown (10YR 3/2) on peds; moderate, fine and medium, subangular blocky structure; firm; common roots; common fine tubular pores; thin, discontinuous clay films of very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2); common small pebbles; slightly acid; gradual, smooth boundary.

B22t—20 to 31 inches, brown (10YR 4/3) clay loam; moderate, medium, prismatic structure parting to moderate, fine and medium, subangular blocky; firm; few roots; few fine tubular pores; thin, discontinuous clay films of dark grayish brown (10YR 4/2); common small pebbles; neutral; clear, wavy boundary.

C1—31 to 40 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) clay loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6), strong brown (7.5YR 5/6), and brown (7.5YR 4/4); weak, medium, subangular blocky structure; friable; few roots; few fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—40 to 60 inches, mixed light brownish-gray (2.5Y 6/2) and yellowish-brown (10YR 5/4) loam; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6), grayish brown (2.5Y 5/2), strong brown (7.5YR 5/6), and brown (7.5YR 4/4); massive; friable; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 20 to 48 inches. The A1 horizon

ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). The A horizon is loam or light clay loam. Reaction in the A horizon is medium acid or slightly acid. The A1 horizon is 6 to 10 inches thick. The A2 horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2). It is loam or light clay loam and is 1 inch to 4 inches thick.

The B2 horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). Reaction in the B21 horizon ranges from slightly acid to strongly acid, and reaction in the B22 horizon ranges from medium acid to neutral.

Lester soils are associated with Clarion and Storden soils. They have a thinner A1 horizon than that of Clarion soils, and they generally have more clay in the B horizon. Lester soils have a thicker and much more acid solum than that of Storden soils.

236F—Lester loam, 18 to 25 percent slopes. This steep soil is on convex side slopes, generally in wooded areas. Areas of this soil are long and narrow and range from 5 to 40 or more acres in size.

Included with this soil in mapping are areas of soils that have a subsoil of heavy clay loam. Also included are small areas of Storden soils and small areas of Lester soils that have slopes of less than 18 percent.

Most areas of this soil are used for woodland and woodland pasture. The soil is poorly suited to row crops. It is very highly susceptible to erosion. Capability unit VIe-1; environmental planting group 1.

236G—Lester loam, 25 to 40 percent slopes. This very steep soil is on convex side slopes, generally in wooded areas. Areas of this soil are long and narrow and range from 5 to 40 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils that have a subsoil of heavy clay loam. Also included are small areas of Storden soils.

Most areas of this soil are used for woodland and woodland pasture. The soil is not suited to row crops. It is very highly susceptible to erosion. Capability unit VIIe-1; environmental planting group 1.

Marcus Series

The Marcus series consists of poorly drained soils on broad flats or in narrow draws adjacent to drainageways on uplands. These soils formed in loess under a native vegetation of prairie grasses that tolerate wetness and, in low places, some swamp grasses and sedges. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is mostly black heavy silty clay loam about 17 inches thick. The subsoil of friable silty clay loam extends to a depth of 44 inches. It is dark gray in the upper part and olive gray in the lower part. The substratum is olive-gray silt loam to a depth of 57 inches and olive-gray loam below.

Marcus soils have moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is medium in the surface layer and very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

Marcus soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Marcus silty clay loam, 0 to 2 percent slopes, in a cultivated field 400 feet south and 70 feet east of the northwest corner of sec. 19, T. 90 N., R. 37 W.:

Ap—0 to 8 inches, black (N 2/0) heavy silty clay loam; weak, fine and medium, subangular blocky structure parting to moderate, fine and medium, granular; friable; many roots; slightly acid; clear, smooth boundary.

A12—8 to 14 inches, black (N 2/0) heavy silty clay loam; moderate, fine and medium, granular structure and weak, very fine, subangular blocky; friable; common roots; few very fine tubular pores; slightly acid; gradual, smooth boundary.

A3—14 to 17 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam or light silty clay; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2); moderate, very fine and fine, subangular blocky structure; friable; common roots; few very fine tubular pores; neutral; clear, smooth boundary.

B21g—17 to 21 inches, dark-gray (5Y 4/1) silty clay loam; few, fine, distinct mottles of yellowish brown (10YR 5/6); coatings of very dark gray (5Y 3/1) and black (10YR 2/1) on peds, very dark gray (5Y 3/1) when kneaded; moderate, very fine and fine, subangular blocky structure; friable; common roots; few very fine tubular pores; few fine segregations and concretions of yellowish-brown (10YR 5/6) and black (10YR 2/1) iron and manganese oxides; neutral; gradual, smooth boundary.

B22g—21 to 30 inches, dark-gray (5Y 4/1) silty clay loam; common, fine, faint and distinct mottles of olive gray (5Y 4/2), dark olive gray (5Y 3/2), and yellowish brown (10YR 5/6 and 10YR 5/8); thin, discontinuous coatings of black (10YR 2/1) and very dark gray (10YR 3/1) on peds in upper part and coatings of very dark gray (10YR 3/1) on peds in lower part; weak, medium, prismatic structure parting to moderate, fine and medium, subangular blocky; friable; few roots; common very fine and fine tubular pores; few fine segregations and concretions of yellowish-brown (10YR 5/6 and 10YR 5/8) and black (10YR 2/1) iron and manganese oxides; neutral; gradual, smooth boundary.

B23—30 to 38 inches, olive-gray (5Y 5/2) silty clay loam; common, fine distinct mottles of yellowish brown (10YR 5/6 and 10YR 5/8); weak, medium, prismatic structure parting to weak and moderate, fine and medium, subangular blocky; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of yellowish-brown (10YR 5/6 and 10YR 5/8) and black (10YR 2/1) iron and manganese oxides; mildly alkaline; gradual, smooth boundary.

B3g—38 to 44 inches, olive-gray (5Y 5/2) silty clay loam; common, fine and medium, distinct mottles of olive brown (2.5Y 4/4), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6); weak, fine and medium, subangular blocky structure; friable; few roots; few fine tubular pores; common, fine, yellowish-brown (10YR 5/6) and black (10YR 2/1) concretions and segregations; mildly alkaline; gradual, smooth boundary.

C1g—44 to 57 inches, olive-gray (5Y 5/2) heavy silt loam; common, fine and medium, distinct mottles of olive brown (2.5Y 4/4), yellowish brown (10YR 5/6 and 10YR 5/8), and strong brown (7.5YR 5/6); very weak, medium, subangular blocky structure; friable; few fine tubular pores; common fine segregations and concretions of strong-brown (7.5YR 5/6) and black (10YR 2/1) iron and manganese oxides; slight effervescence; moderately alkaline; clear, wavy boundary.

IIC2g—57 to 62 inches, olive-gray (5Y 5/2) to light olive-gray (5Y 6/2) loam; common, fine and medium, distinct mottles of strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6) and 10YR 5/8); massive, friable; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; few fine segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 30 to 54 inches. Depth to calcareous material ranges from 24 to 48 inches. The A1 horizon is black (N 2/0 or 10YR 2/2). It is silty clay loam or light silty clay and is 14 to 24 inches thick. Reaction in the A horizon is slightly acid or neutral.

The B2 horizon ranges from dark gray (5Y 4/1) to grayish brown (2.5Y 5/2). Reaction in the B2 horizon ranges from neutral to moderately alkaline. The B1 horizon, if present, is silty clay loam or light silty clay, and the B3 horizon is silty clay loam or heavy silt loam. The B horizon is 14 to 36 inches thick.

The C1g horizon, if it is loess, is gray (5Y 5/1) or olive gray (5Y 5/2) and is light silty clay loam or silt loam. Depth to the glacial till IIC horizon generally ranges from 40 to 60 inches, but in places it is 7 or 8 feet.

Marcus soils are associated with Afton and Primghar soils. Their A horizon is thinner than that of Afton soils, and their B horizon is grayer than that of Primghar soils.

92—Marcus silty clay loam, 0 to 2 percent slopes. This nearly level soil is on broad flats or in narrow draws on uplands. Areas of this soil are irregular or long and narrow in shape and range from 4 to 50 or more acres in size.

Included with this soil in mapping are small areas of Afton and Primghar soils.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to corn, soybeans, small grain, and alfalfa. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw-2; environmental planting group 2.

Marsh

354—Marsh. This mapping unit consists of low areas that are covered by water most of the time. Individual areas range from 10 to 100 acres in size.

Most of these areas are used mainly for wildlife habitat. Capability unit VIIw-1; environmental planting group 2.

Millington Series

The Millington series consists of poorly drained soils on bottom lands in the present flood plains of meandering streams. These soils formed in loamy alluvium, generally under a native vegetation of swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer extends to a depth of 72 inches. In sequence from the top, it is 13 inches of mixed black and very dark gray loam, 5 inches of very dark gray silt loam, 17 inches of very dark gray loam, and 37 inches of black loam.

Millington soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus and available potassium ranges from very low to low in both the surface layer and the underlying material. Reaction is moderately alkaline or mildly alkaline in the surface layer.

Millington soils are mainly in pasture or in trees and brush (fig. 13). The major limitations in cultivated areas are frequent flooding and wetness.

Representative profile of Millington loam, channeled, 0 to 2 percent slopes, in a wooded area 840 feet north and 700 feet east of the southwest corner of sec. 11, T. 93 N., R. 38 W.:

A11—0 to 6 inches, mixed black (10YR 2/1) and very dark gray (10YR 3/1) loam; weak, fine, subangular blocky structure; friable; common roots; slight effervescence; moderately alkaline; clear, smooth boundary.

A12—6 to 13 inches, mixed black (10YR 2/1) and very dark gray (10YR 3/1) loam; weak, fine, subangular blocky structure; friable; common roots; few fine tubular pores; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A13—13 to 18 inches, very dark gray (10YR 3/1) silt loam; moderate, medium, platy structure (because of stratification); friable; few roots; few fine tubular pores; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A14—18 to 28 inches, very dark gray (10YR 3/1) loam; moderate, fine, subangular blocky structure; friable; few roots; few fine tubular pores; slight effervescence; moderately alkaline clear, smooth boundary.

A15—28 to 35 inches, very dark gray (10YR 3/1) loam; moderate, medium, platy structure (because of stratification); friable; few roots; few fine tubular pores; slight effervescence; moderately alkaline; clear, smooth boundary.

A11b—35 to 40 inches, black (10YR 2/1) loam; weak, fine and medium, subangular blocky structure; friable; few roots; few fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

A12b—40 to 54 inches, black (10YR 2/1) loam; weak, fine and medium, subangular blocky structure; friable; few roots; few fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

A13b—54 to 63 inches, black (10YR 2/1) loam; weak, fine and medium, subangular blocky structure; friable; few fine tubular pores; slight effervescence; moderately alkaline; clear, smooth boundary.

A14b—63 to 72 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; few fine tubular pores; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 36 to more than 72 inches. The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is loam or silt loam that is high in content of sand and is 36 to more than 72 inches thick. Reaction in the A horizon is moderately alkaline or mildly alkaline.

In many places a black (10YR 2/1 or N 2/0) Ab horizon is present below a depth of about 3 feet. In some profiles a weak structural B horizon or AC horizon is present.

The C horizon ranges from very dark gray (10YR 3/1) to gray (5Y 5/1) or olive gray (5Y 5/2). It generally is loam, but in places it is silt loam, clay loam, or silty clay loam.

Millington soils in this county have a thicker A horizon and more stratification in the upper part of the solum than is defined in the range for the series. Also, a buried soil generally is not in the Millington soils. These differences do not significantly affect the use or behavior of the soils.

Millington soils are associated with Colo and Spillville soils. Unlike Colo and Spillville soils, they have a calcareous solum. Millington soils have more sand and less clay in the solum than Colo soils.

C458—Millington loam, channeled, 0 to 2 percent slopes. This nearly level, calcareous soil is on flood plains of meandering streams. It is characteristically dissected by many channels. Areas of this soil are long and narrow and generally range from 10 to 100 or more acres in size.

Included with this soil in mapping are small areas of Colo and Spillville soils. Also included are areas of soils that have stratified sand and sandy loam.

Most areas of this soil are used for pasture and woodland. The soil is poorly suited to row crops. It is susceptible to frequent flooding. Capability unit Vw-1; environmental planting group 2.

Nicollet Series

The Nicollet series consists of somewhat poorly drained soils on the Wisconsin (Cary) till plain. These soils generally formed in loamy glacial till. In some areas, however, they formed in moderately fine textured sediment and the underlying glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

In a representative profile the surface layer is about 20 inches thick. It is black loam in the upper part, very dark gray loam in the middle part, and very dark gray light clay loam in the lower part. The subsoil extends to a depth of 34 inches. It is mixed dark grayish-brown and very dark grayish-brown, friable light clay loam in the upper part and dark grayish-brown, friable loam in the lower part. The substratum is grayish-brown to a depth of 46 inches and mixed light brownish-gray and yellowish-brown loam to a depth of 60 inches.

Nicollet soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium is low

Figure 13.—**This wooded area on the Little Sioux River bottom is mainly Millington loam, channeled. Note the meandering channels through the scrub and brush timber. The wooded area across the road is frequently flooded, and the cultivated area across the river is on a stream terrace of mainly Wadena soils.**

or medium in the surface layer and very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

Nicollet soils are used mainly for cultivated crops. During wet periods wetness is a slight limitation in cultivated areas.

Representative profile of Nicollet loam, 1 to 3 percent slopes, in a cultivated field 550 feet north and 70 feet west of the southeast corner of sec. 20, T. 91 N., R. 35 W.:

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, fine and medium, granular structure; friable; many roots; common fine tubular pores; common small pebbles; neutral; abrupt, smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1) loam; coatings of black (10YR 2/1) on peds; weak, fine, subangular blocky structure parting to weak, fine and medium, granular; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A3—16 to 20 inches, very dark gray (10YR 3/1) light clay loam; common fine peds of very dark grayish brown (10YR 3/2); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine, subangular blocky structure parting to weak, fine, granular; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B21—20 to 23 inches, mixed dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (10YR 3/2) light clay loam; thin, discontinuous coatings of very dark gray (10YR 3/1) and black (10YR 2/1) on peds, dark grayish brown (2.5Y 4/2) when kneaded; weak, fine, subangular blocky structure; friable; common roots; common fine tubular pores; few fine segregations and concretions of yellowish-brown (10YR 5/6), brown (7.5YR 4/4), and very dark gray (10YR 3/1) iron and manganese oxides; common small pebbles; neutral; gradual, smooth boundary.

B22—23 to 27 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, faint mottles of very dark grayish brown (2.5Y 3/2) and olive brown (2.5Y 4/4); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; few fine segregations and concretions of yellowish-brown (10YR 5/6), brown (7.5YR 4/4), and very dark gray (10YR 3/1) iron and manganese oxides; common small pebbles; neutral; gradual, smooth boundary.

B23—27 to 34 inches, dark grayish-brown (2.5Y 4/2) loam; common, fine, faint mottles of olive brown (2.5Y 4/4); common, discontinuous coatings of very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) on peds; weak, medium, subangular blocky structure; friable; few roots; common fine tubular pores; common fine and medium segregations and concretions of yellowish-brown (10YR 5/6), brown (7.5YR 4/4), and very dark gray (10YR 3/1) iron and manganese oxides; common small pebbles; neutral; clear, wavy boundary.

C1—34 to 46 inches, grayish-brown (2.5Y 5/2) loam; common, fine, faint mottles of dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4); very weak, medium, subangular blocky structure; friable; few roots; common fine and medium segregations and concretions of yellowish-brown (10YR 5/6), brown (7.5YR 4/4), and very dark gray (10YR 3/1) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—46 to 60 inches, mixed light brownish-gray (2.5Y 6/2) and yellowish-brown (10YR 5/4) loam; common, fine and medium, faint and distinct mottles of grayish brown (2.5Y 5/2), yellowish brown (10YR 5/6), and brown (7.5YR 4/4); massive; friable; common fine tubular pores; common fine and medium segregations and concretion of yellowish-brown (10YR 5/6), brown (7.5 YR 4/4), and very dark gray (10YR 3/1) iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 20 to 48 inches. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1). It is heavy loam, light clay loam, or silty clay loam and is 14 to 24 inches thick. Reaction is neutral or slightly acid.

The B2 horizon is dark grayish brown (2.4Y 4/2 or 10YR 4/2). It generally is loam or light clay loam. In places, however, it is silty clay loam in the upper part. Reaction in the B2 horizon ranges from slightly acid to mildly alkaline.

The C horizon ranges from light grayish brown (2.5Y 6/2) to yellowish brown (10YR 5/4). It is loam or light clay loam.

Nicollet silty clay loam, 1 to 3 percent slopes, has more silt and clay than is defined in the range for the series. This difference does not significantly affect the use and behavior of the soil.

Nicollet soils are associated with Clarion and Webster soils and have similar drainage to the Primghar soils. They have a grayer B horizon and a slightly thicker A horizon than Clarion soils. They lack the gray, gleyed B horizon that is characteristic of Webster soils. Nicollet soils contain more sand than Primghar soils.

55—Nicollet loam, 1 to 3 percent slopes. This nearly level soil is on glacial till uplands. Areas of this soil are irregular in shape and range from 4 to 40 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are small areas of Collinwood and Cylinder soils. Also included are areas of soils that have a calcareous surface layer.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, small grain, and alfalfa. In cultivated areas it has a slight limitation because of wetness in wet years. Capability unit I–1; environmental planting group 1.

251—Nicollet silty clay loam, 1 to 3 percent slopes. This nearly level soil is on uplands. It has slightly convex slopes. Areas of this soil range from 4 to 50 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer and the upper part of the subsoil are silty clay loam or clay loam. It formed in moderately fine textured sediment and the underlying glacial till. Included in mapping are small areas of Collinwood, Okoboji, and Rolfe soils.

Most areas of this soil are cultivated. The soil is well suited to row crops. In cultivated areas it has a slight limitation because of wetness in wet years. Capability unit I–1; environmental planting group 1.

Okoboji Series

The Okoboji series consists of very poorly drained soils in distinct, landlocked upland depressions of the Wisconsin (Cary) till plain. These soils formed in silty, moderately fine textured, local alluvium under a native vegetation of swamp grasses and sedges. Slopes range from 0 to 1 percent.

In a representative profile the surface layer is black silty clay loam about 34 inches thick. The subsoil extends to a depth of 58 inches. It is very dark gray, firm light silty clay in the upper part and very dark gray, firm heavy silty clay loam in the lower part. The substratum extends to a depth of 87 inches. It is olive-gray heavy silty clay loam and loam.

Okoboji soils have moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus is medium or high in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and very low or low in the subsoil. Reaction generally is neutral in the surface layer.

Okoboji soils are used mainly for cultivated crops. The major limitations in cultivated areas are wetness and ponding on the surface.

Representative profile of Okoboji silty clay loam, 0 to 1 percent slopes, in a pasture 360 feet south and 1,170 feet west of the northeast corner of sec. 23, T. 92 N., R. 36 W.:

A11—0 to 10 inches, black (N 2/0) silty clay loam; moderate, fine and medium, granular structure; friable; common roots; common very fine and fine tubular pores; neutral; clear, smooth boundary.

A12—10 to 20 inches, black (N 2/0) heavy silty clay loam; weak, medium, subangular blocky structure parting to weak, fine and medium, granular; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

A13—20 to 27 inches, black (10YR 2/1) heavy silty clay loam; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

A3—27 to 34 inches, black (10YR 2/1) heavy silty clay loam; weak, fine and medium, subangular blocky structure; firm; few roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B2g—34 to 48 inches, very dark gray (10YR 3/1) light silty clay; weak, fine and medium, subangular blocky structure; firm; few roots; common very fine and fine tubular pores; mildy alkaline; clear, wavy boundary.

B3g—48 to 58 inches, very dark gray (5Y 3/1) heavy silty clay loam; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2); weak, fine and medium, subangular blocky structure; firm; few roots; common fine and medium segregations and concretions of iron and manganese oxides; common, fine and medium segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline; abrupt, wavy boundary.

C1g—58 to 76 inches, olive-gray (5Y 5/2) heavy silty clay loam; common, fine and medium, distinct mottles of brown (7.5YR 4/4), strong brown (7.5YR 5/6), light olive brown (2.5Y 5/4), and yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; firm; common very fine and fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline; clear, wavy boundary.

IIC2g—76 to 87 inches, olive-gray (5Y 5/2 and 5Y 4/2) loam; common, fine and medium, distinct mottles of brown (7.5YR 4/4), strong brown (7.5YR 5/6), light olive brown (2.5Y 5/4), and yellowish brown (10YR 5/6); massive; friable; common very fine and fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 40 to about 60 inches. The A1 horizon is black (N 2/0 or 10YR 2/1) and is 24 to 36 inches thick. The lower part of the A1 horizon is heavy silty clay loam or light silty clay. Reaction in the A horizon is neutral or mildly alkaline.

The Bg horizon ranges from very dark gray (10YR 3/1) to olive gray (5Y 5/2). It is heavy silty clay loam or light silty clay. Reaction is neutral to moderately alkaline.

The Cg horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2). It is silty clay loam, clay loam, or loam. Reaction in the Cg horizon is mildly alkaline or moderately alkaline.

Okoboji soils, like the Wacousta soils, are very poorly drained and in depressions. Okoboji soils are similar in color to Colo soils. They contain more clay than Colo and Wacousta soils. Okoboji soils have a thicker A horizon than that of Wacousta soils.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This soil is in distinct landlocked depressions on glacial till uplands. Areas of this soil are irregular in shape and generally range from 2 to 8 or more acres in size.

Included with this soil in mapping are areas of soils that have a calcareous surface layer. Also included are areas of soils that have strata of sand and gravel below a depth of 32 inches.

Most areas of this soil are cultivated. The soil is moderately well suited to row crops. It is highly susceptible to ponding and generally has a high water table. In cultivated areas it has a severe limitation because of wetness. Capability unit IIIw–1; environmental planting group 2.

Primghar Series

The Primghar series consists of somewhat poorly drained

soils that generally are on broad flats on uplands but are also in long, narrow, concave draws. Primghar soils formed in loess under a native vegetation of prairie grasses. Slopes range from 0 to 4 percent.

In a representative profile the surface layer is about 18 inches thick. It is black silty clay loam in the upper part and very dark grayish-brown silty clay loam in the lower part. The subsoil extends to a depth of 48 inches. It is dark grayish-brown, friable silty clay loam in the upper part and mixed dark grayish-brown and light olive-brown, friable silt loam in the lower part. The substratum is mixed dark grayish-brown and grayish-brown silt loam.

Primghar soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction generally is slightly acid or medium acid in the surface layer.

Primghar soils are used mainly for cultivated crops. The major limitation in cultivated areas is a slight wetness during wet periods.

Representative profile of Primghar silty clay loam, 0 to 2 percent slopes, in a cultivated field 1,520 feet north and 120 feet west of the southeast corner of NE1/4 sec. 5, T. 93 N., R. 38 W.:

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; moderate, fine, granular structure; friable; common roots; slightly acid; abrupt, smooth boundary.

A12—7 to 13 inches, black (10YR 2/1) silty clay loam; moderate, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; common roots; few fine tubular pores; slightly acid; gradual, smooth boundary.

A3—13 to 18 inches, very dark grayish-brown (10YR 3/2) silty clay loam; common peds of very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2); coatings of black (10YR 2/1) on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; few very fine and fine tubular pores; slightly acid; clear, smooth boundary.

B21—18 to 25 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; thin, discontinuous coatings of very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; few very fine and fine tubular pores; few fine segregations and concretions of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B22—25 to 31 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, faint and distinct mottles of brown (10YR 4/3), dark yellowish brown (10YR 4/4), and yellowish brown (10YR 5/4); weak fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B23—31 to 38 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, distinct and faint mottles of brown (10YR 4/3), dark yellowish brown (10YR 4/4), and dark gray (10YR 4/1); weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

B31—38 to 43 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, distinct and faint mottles of brown (10YR 4/3), dark yellowish brown (10YR 4/4), and dark gray (10YR 4/1); weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

B32—43 to 48 inches, mixed dark grayish-brown (10YR 4/2) and light olive-brown (2.5Y 5/4) silt loam; common, medium, faint and distinct mottles of yellowish brown (10YR 5/6), grayish brown (10YR 5/2), and dark gray (10YR 4/1); weak, medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; neutral; gradual, smooth boundary.

C1—48 to 52 inches, mixed dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) silt loam; common, fine and medium, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); massive; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; few fine and medium concretions of calcium carbonate; slight effervescence; mildly alkaline; gradual, smooth boundary.

C2—52 to 60 inches, mixed dark grayish brown (10YR 4/2) and grayish-brown (10YR 5/2) silt loam; common, fine and medium, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); massive; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum generally ranges from 30 to 50 inches. The A1 horizon is black (10YR 2/1 or N 2/0) or very dark brown (10YR 2/2). The A horizon is 16 to 22 inches thick. Reaction in the A horizon generally is slightly acid or medium acid.

The B2 horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (10YR 5/2 or 2.5Y 5/2). The B3 horizon is silty clay loam or silt loam. The B horizon is 14 to 32 inches thick. Reaction in the B horizon ranges from slightly acid to mildly alkaline except the B3 horizon is moderately alkaline in places.

The C1 horizon, if it is loess, is silt loam or light silty clay loam. Depth to the glacial till IIC horizon ranges from 40 to 96 inches or more.

Primghar soils are associated with Marcus, Galva, and Sac soils. They do not have the gleyed, gray B horizon that is characteristic of Marcus soils. They have a grayer B horizon than those of Galva and Sac soils. Unlike Sac soils, which formed in 24 to 36 inches of loess and the underlying glacial till, Primghar soils formed entirely in loess.

91—Primghar silty clay loam, 0 to 2 percent slopes. This nearly level soil generally is on broad flats on uplands. Areas of this soil are irregular in shape and range from 10 to 100 or more acres in size.

This soil has the profile described as representative of the series.

Most areas of this soil are cultivated. The soil is well suited to corn, soybeans, small grain, and alfalfa. In cultivated areas it has a slight limitation because of wetness in wet years. Capability unit I–1; environmental planting group 1.

91B—Primghar silty clay loam, 2 to 4 percent slopes. This gently sloping soil is in long, narrow, concave draws. Areas are long and narrow in shape and range from 4 to 50 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thicker. Included in mapping are small areas of Afton and Marcus soils in the center of the drainageways.

Most areas of this soil are cultivated. Where runoff from adjacent soils is controlled, the soil is well suited to row crops. It is subject to runoff from adjacent slopes and is moderately susceptible to erosion. Capability unit IIe–2; environmental planting group 1.

Rolfe Series

The Rolfe series consists of very poorly drained soils in shallow potholes and other depressions of the gently undulating Wisconsin (Cary) till plain. These soils formed in glacial drift and local alluvium under a native vegetation of swamp grasses and sedges. Slopes range from 0 to 1 percent.

In a representative profile the surface layer is black silt loam about 9 inches thick. The subsurface layer is dark-gray

silt loam about 8 inches thick. The subsoil extends to a depth of 47 inches. It is mixed very dark gray and olive-gray, firm silty clay in the upper part; olive-gray, firm heavy clay loam in the middle part; and olive-gray, friable loam in the lower part. The substratum is olive-gray loam.

Rolfe soils have slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. Unless these soils are limed, reaction is medium acid or slightly acid in the surface layer.

Rolfe soils are used mainly for cultivated crops. The major limitations in cultivated areas are wetness and ponding.

Representative profile of Rolfe silt loam, 0 to 1 percent slopes, in a cultivated field 600 feet north and 189 feet west of the southeast corner of SW1/4 sec. 2, T. 93 N., R. 36 W.:

Ap—0 to 9 inches, black (10YR 2/1) heavy silt loam; moderate, fine, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A2—9 to 17 inches, dark-gray (10YR 4/1) silt loam; discontinuous coatings of black (10YR 2/1) on peds; moderate, medium and thick, platy structure; friable; common roots; common fine tubular pores; slightly acid; clear, smooth boundary.

B21tg—17 to 21 inches, very dark gray (5Y 3/1) and olive-gray (5Y 5/2) silty clay; few, fine distinct mottles of strong brown (7.5 YR 5/6); moderate, fine and medium, prismatic structure parting to moderate, fine and medium, angular and subangular blocky; firm; few roots; common fine tubular pores; common discontinuous coatings of silt on prisms; thin, continuous clay films of very dark gray (5Y 3/1) on peds; common fine segregations and concretions of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B22tg—21 to 28 inches, very dark gray (5Y 3/1) and olive-gray (5Y 5/2) silty clay; common, fine, distinct mottles of strong brown (7.5YR 5/6); prismatic structure parting to moderate, fine and medium, angular and subangular blocky; firm; few roots; few fine tubular pores; thin, continuous clay films of very dark gray (5Y 3/1) on peds; common fine segregations and concretions of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B23tg—28 to 35 inches, olive-gray (5Y 5/2) heavy clay loam; common, fine and medium, distinct mottles of strong brown (7.5YR 5/6) and brown (7.5YR 4/4); moderate, fine and medium, subangular blocky structure; firm; few roots; few fine tubular pores; thin, discontinuous clay films of very dark gray (5Y 3/1) on peds; common fine and medium segregations and concretions of iron and manganese oxides; slightly acid; gradual, smooth boundary.

B3tg— 35 to 47 inches, olive-gray (5Y 5/2) loam; common, fine and medium, subangular blocky structure; friable; few fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common small pebbles; neutral; gradual, wavy boundary.

Cg—47 to 68 inches, olive-gray (5Y 5/2) loam; common, fine and medium, faint and distinct mottles of grayish brown (2.5Y 5/2), very dark gray (5Y 3/1), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), brown (7.5YR 4/4), and strong brown (7.5YR 5/6); massive; friable; common fine and medium segregations and concretions of iron and manganese oxides; few fine segregations of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 42 to 54 inches. The A1 horizon is black (10YR 2/1) or very dark gray (10YR 3/1). It is silt loam or silty clay loam. Reaction in the A1 horizon ranges from medium acid to neutral. The A2 horizon generally ranges from dark gray (10YR 4/1) to gray (10YR 6/1) and is 4 to 8 inches thick.

The Btg horizon ranges from very dark gray (5Y 3/1) to olive gray (5Y 5/2). The B21tg horizon is silty clay or clay. The B3tg horizon is clay loam or loam. Reaction in the B2tg horizon is slightly acid or neutral.

The Cg horizon is olive-gray (5Y 4/2 or 5Y 5/2) loam or clay loam. Reaction in the Cg horizon ranges from neutral to moderately alkaline.

Rolfe soils formed in parent material similar to that of the Okoboji soils. They have more clay in the B horizon than Okoboji soils and, unlike those soils, they have a gray A2 horizon.

274—Rolfe silt loam, 0 to 1 percent slopes. This soil is in shallow potholes and other depressions on the gently undulating glacial till plain. Areas of this soil are irregular in shape and generally range from 2 to 4 or more acres in size.

Included with this soil in mapping are areas of soils that have a substratum of silty clay loam.

Most areas of this soil are cultivated. The soil is moderately well suited to row crops. It is highly susceptible to ponding and generally has a high water table. In cultivated areas it has a severe limitation because of wetness. Capability unit IIIw–1; environmental planting group 2.

Sac Series

The Sac series consists of well-drained soils on uplands (fig. 14). These soils formed in loess that generally is 24 to 36 inches thick and in the underlying calcareous loam or clay loam glacial till. The native vegetation was prairie grasses. Slopes are convex and range from 2 to 9 percent.

In a representative profile the surface layer is about 12 inches thick. It is very dark brown silty clay loam in the upper part and very dark grayish-brown heavy silty clay loam in the lower part. The subsoil extends to a depth of 38 inches. It is dark-brown and brown, friable silty clay loam in the upper part; brown, friable silty clay loam in the upper middle part; brown, friable light clay loam in the lower middle part; and yellowish-brown, friable loam in the lower part. The substratum is yellowish-brown loam (fig. 15).

Sac soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from high to moderately low. The content of available phosphorus generally is low in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction is slightly acid or medium acid in the surface layer.

Sac soils are used mainly for cultivated crops. The major limitation in cultivated areas is erosion.

Representative profile of Sac silty clay loam, loam substratum, 2 to 5 percent slopes, in a cultivated field 450 feet north and 168 feet west of the southeast corner of SW1/4 sec. 22, T. 92 N., R. 38 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam; weak, medium, subangular blocky structure parting to weak, fine, granular; friable; many roots; slightly acid; abrupt, smooth boundary.

A3—8 to 12 inches, very dark grayish-brown (10YR 3/2) heavy silty clay loam; few peds of dark brown (10YR 3/3) and brown (10YR 4/3); coatings of very dark brown (10YR 2/2) on peds; moderate, very fine and fine, subangular blocky structure; friable; many roots; common fine tubular pores; slightly acid; clear, smooth boundary.

B21—12 to 15 inches, dark-brown (10YR 3/3) heavy silty clay loam; few peds of brown (10YR 4/3); thin discontinuous coatings of very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) on peds; moderate, fine, subangular blocky structure; friable; common roots; few fine tubular pores; slightly acid; clear, smooth boundary.

B22—15 to 22 inches, brown (10YR 4/3) silty clay loam; thin, discontinuous coatings of dark brown (10YR 3/3) on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; few fine tubular pores; slightly acid; gradual, smooth boundary.

B23—22 to 28 inches, brown (10YR 4/3) silty clay loam; thin, discon-

Figure 14.—Long, gentle and moderate slopes of Sac silty clay loam, loam substratum.

Figure 15.—Profile of Sac silty clay loam, loam substratum. Note that the subsoil extends into the underlying loam substratum. Arrow indicates point where loam begins.

tinuous coatings of dark brown (10YR 3/3) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; few fine tubular pores; neutral; gradual, smooth boundary.

IIB24—28 to 34 inches, brown (10YR 4/3) light clay loam; weak, fine and medium, subangular blocky structure; friable; common roots; few fine tubular pores; neutral; abrupt, wavy boundary.

IIB3—34 to 38 inches, yellowish-brown (10YR 5/6) loam; common, medium, distinct mottles of grayish brown (10YR 5/2), brown (10YR 4/3), and yellowish brown (10YR 5/4); weak, medium, subangular blocky structure; friable; few roots; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small segregations and concretions of calcium carbonate; common small pebbles; mildly alkaline; abrupt, wavy boundary.

IIC1—38 to 58 inches, yellowish-brown (10YR 5/4) loam; common, medium, distinct mottles of strong brown (7.5YR 5/6), brown (10YR 5/3), dark yellowish brown (10YR 4/4), light brownish gray (10YR 6/2), and yellowish brown (10YR 5/6); massive; friable; few roots; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

IIC2—58 to 70 inches, yellowish-brown (10YR 5/4) loam; common, medium, distinct mottles of light brownish gray (10YR 6/2), grayish brown (10YR 5/2), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6); massive; friable; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small segregations and concretions of calcium carbonate; few small pebbles; strong effervescence; moderately alkaline.

Representative profile of Sac silty clay loam, clay loam substratum, 2 to 5 percent sopes, in a cultivated field 186 feet north and 120 feet east of the southwest corner of NW1/4 sec. 32, T. 90 N., R. 38 W.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam; moderate, fine, subangular blocky structure parting to moderate, fine and medium, granular; friable; common roots; slightly acid; abrupt, smooth boundary.

A3—8 to 13 inches, very dark grayish-brown (10YR 3/2) silty clay loam; very dark gray (10YR 3/1) coatings on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; slightly acid; gradual, smooth boundary.

B21—13 to 16 inches, dark-brown (10YR 3/3) silty clay loam; common, fine, faint mottles of brown (10YR 4/3); thin, discontinuous, very dark grayish-brown (10YR 3/2) and very dark gray (10YR 3/1) coatings on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; few, thin, discontinuous clay films of very dark grayish brown (10YR 3/2) on peds; neutral; gradual, smooth boundary.

B22—16 to 21 inches, brown (10YR 4/3) silty clay loam; thin, discontinuous very dark grayish-brown (10YR 3/2) coatings on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; gradual, smooth boundary.

B23—21 to 27 inches, brown (10YR 4/3) silty clay loam; thin, discontinuous very dark grayish-brown (10YR 3/2) coatings on peds; moderate, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; neutral; abrupt, wavy boundary.

IIB3—27 to 33 inches, brown (10YR 4/3) clay loam; few, fine, faint dark grayish-brown (10YR 4/2) mottles; weak, fine, prismatic structure parting to moderate, fine and medium, subangular blocky; firm; few roots; common very fine and fine tubular pores; common fine segregations of iron and manganese oxides; slight effervescence; mildly alkaline; gradual, wavy boundary.

IIC1—33 to 44 inches, brown (10YR 4/3) clay loam; common, fine and medium, faint and distinct yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6), dark grayish-brown (10YR 4/2), grayish-brown (10YR 5/2), and light brownish-gray (2.5Y 6/2); mottles weak, coarse, subangular blocky structure; firm; few roots; common fine tubular pores; common fine segregations of iron and manganese oxides; common medium and coarse segregations and concretions of calcium carbonate; moderately alkaline; strong effervescence; gradual, wavy boundary.

IIC2—44 to 60 inches, brown (10YR 4/3) clay loam; common, fine and medium, faint and distinct yellowish brown (10YR 5/6), strong brown (7.5YR 5/6), and grayish brown (10YR 5/2) mottles; massive; firm; common fine tubular pores; common fine segregations of iron and manganese oxides; common medium and coarse segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 30 to 48 inches. Thickness of loess generally is 24 to 36 inches. In places, however, it ranges from 20 to 40 inches. The A1 or Ap horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The A horizon is 10 to 14 inches thick unless eroded. Reaction in the A horizon generally is slightly acid or medium acid.

The B2 horizon is dark brown (10YR 3/3), brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). Reaction in the B2 horizon generally is slightly acid or neutral.

The IIB and IIC horizons range from brown (10YR 4/3) to yellowish brown (10YR 5/4) and have mottles of strong brown (7.5YR 5/6) or yellowish brown (10YR 5/6) and dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). The IIC horizon is loam or clay loam.

Sac soils are associated with Galva and Everly soils, and they have somewhat similar profiles. They have a thinner loess layer than that of Galva soils. Sac soils have less sand in the A horizon and in the upper part of the B horizon than Everly soils.

77B—Sac silty clay loam, loam substratum, 2 to 5 percent slopes. This gently sloping soil is on convex slopes on uplands. Areas of this soil are irregular in shape and range from 10 to 100 or more acres in size.

This soil has the profile described as representative of the loam substratum phase of the Sac series. Included in mapping are small areas of Everly, Galva, and Storden soils.

Most areas of this soil are cultivated. Where erosion is controlled, the soil is well suited to row crops (fig. 16). It is moderately susceptible to erosion. The content of organic matter in the surface layer is moderate or high. Capability unit IIe-1; environmental planting group 1.

77C2—Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex side slopes on uplands. Areas of this soil are long and narrow in shape and range from 4 to 50 or more acres in size.

This soil has a profile similar to the one described as representative of the loam substratum phase of the Sac series, but the surface layer is a few inches thinner. Included in mapping are small areas of Everly and Storden soils. Also included are areas of soils that have slopes of more than 9 percent and areas of soils that are are only slightly eroded.

Most areas of this soil are used for cultivated crops. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–1; environmental planting group 1.

78B—Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes. This soil is on loess-covered uplands. Slopes are gentle and convex. Areas of this soil are irregular in shape and range from 10 to 100 or more acres in size.

This soil has the profile described as representative of the clay loam substratum phase of the Sac series.

Most areas of this soil are cultivated. Where erosion is controlled, the soil is well suited to row crops. It is moderately susceptible to erosion. The content of organic matter in the surface layer is moderate or high. Capability unit IIe–1; environmental planting group 1.

78C2—Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex side slopes on loess-covered uplands. Areas of this soil are long and narrow and range from 4 to 50 or more acres in size.

This soil has a profile similar to the one described as representative of the clay loam substratum phase of the Sac series, but the surface layer is thinner. Included in mapping are small areas of soils that have slopes of more than 9 percent.

Most areas of this soil are cultivated. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is moderately low or moderate. Capability unit IIIe–1; environmental planting group 1.

***Figure 16.*—Gently sloping Sac silty clay loam, loam substratum, in a cultivated field south of Storm Lake. Note island of Fill land in center of lake.**

Salida Series

The Salida series consists of excessively drained soils on small kames or knobs on uplands and on glacial outwash plains. These soils formed in calcareous, sandy and gravelly glacial deposits under a native vegetation of prairie grasses. Slopes range from 5 to 14 percent.

In a representative profile the surface layer is very dark brown gravelly sandy loam about 7 inches thick. The subsoil extends to a depth of 12 inches. It is brown, very friable gravelly sandy loam. The substratum is dark yellowish-brown gravelly sand to a depth of 33 inches and yellowish-brown loamy sand and gravel below.

Salida soils have very rapid permeability and very low available water capacity. The content of organic matter in the surface layer is low or very low. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low in the surface layer and very low in the subsoil. Reaction generally is moderately alkaline or mildly alkaline in the surface layer.

Salida soils are used for permanent pasture and cultivated crops. The major limitations in cultivated areas or pasture are very low available water capacity and erosion.

Representative profile of Salida gravelly sandy loam, 9 to 14 percent slopes, in permanent pasture 1,000 feet south and 825 feet east of the northwest corner of NE1/4 sec. 19, T. 90 N., R. 36 W.:

A1—0 to 7 inches, very dark brown (10YR 2/2) gravelly sandy loam; weak, fine and medium, granular structure; very friable; common roots; strong effervescence; moderately alkaline; abrupt, smooth boundary.

B2—7 to 12 inches, brown (10YR 5/3) gravelly sandy loam; very weak, fine and medium, subangular blocky structure; very friable; common roots; strong effervescence; moderately alkaline; clear, wavy boundary.

C1—12 to 33 inches, dark yellowish-brown (10YR 4/4) gravelly sand; single grained; loose; few roots; strong effervescence; moderately alkaline; gradual, wavy boundary.

C2—33 to 60 inches, yellowish-brown (10YR 5/4) loamy sand and gravel; single grained; loose; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 7 to 18 inches. The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It is gravelly sandy loam, gravelly loam, or sandy loam and is 7 to 10 inches thick unless eroded. Reaction in the A horizon ranges from slightly acid to moderately alkaline.

The B2 horizon, if present, is brown (10YR 5/3 or 4/3), dark brown (10YR 3/3), or dark yellowish brown (10YR 4/4 or 3/4). It ranges from gravelly sandy loam to gravelly sand.

The C horizon generally ranges from yellowish brown (10YR 5/4) to dark grayish brown (10YR 4/2). It ranges from loamy sand and gravel to gravelly sand to gravel. It also includes stratified sand, coarse sand, or gravel.

Salida soils and their parent material is similar to that of the Estherville soils. They are associated with Storden and Clarion soils, contain much more sand and gravel than Storden and Clarion soils. Unlike Clarion soils, which are leached to a depth of 24 to 40 inches, Salida soils are calcareous at depths of less than 16 inches. Salida soils are shallower to sand and gravel than Estherville soils.

73C—Salida gravelly sandy loam, 5 to 9 percent slopes. This moderately sloping soil is on small kames or knobs on glacial till plains. Areas of this soil are long and narrow or irregular in shape and range from 2 to 8 acres in size.

Included with this soil in mapping are small areas of Estherville and Storden soils.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It has very low available water capacity and is highly susceptible to both water erosion and soil blowing. The content of organic matter in the surface layer is low or very low. Capability unit IVs–1; environmental planting group 4.

73D—Salida gravelly sandy loam, 9 to 14 percent slopes. This strongly sloping soil is on small kames or knobs on glacial till plains and on glacial outwash stream terraces where slopes are convex. Areas of this soil are long and narrow or irregular in shape and generally range from 2 to 12 acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of Estherville and Storden soils.

Most areas of this soil are used for pasture and cultivated crops. The soil is poorly suited to row crops. It has very low available water capacity and is highly susceptible to both water erosion and soil blowing. The content of organic matter in the surface layer is low or very low. Capability unit VIs–1; environmental planting group 4.

Spicer Series

The Spicer series consists of calcareous, poorly drained soils on moderately broad flats and in narrow draws on uplands. These soils formed in loess under a native vegetation of prairie grasses that tolerate wetness and under swamp grasses and sedges. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 23 inches thick. It is black silty clay loam in the upper part and very dark gray silty clay loam in the lower part. The subsoil of friable silty clay loam extends to a depth of 41 inches. It is dark gray in the upper part and olive gray in the lower part. The substratum is olive-gray silt loam to a depth of 54 inches and mixed olive-gray and olive-brown loam below.

Spicer soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus is very low or low in the surface layer and very low in the subsoil. The content of available potassium is low in the surface layer and very low or low in the subsoil. Reaction is moderately alkaline in the surface layer.

Spicer soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Spicer silty clay loam, 0 to 2 percent slopes, in a cultivated field 525 feet south and 150 feet east of the northwest corner of sec. 16, T. 92 N., R. 38 W.:

Ap—0 to 9 inches, black (N 2/0) silty clay loam; cloddy parting to weak, fine, granular structure; friable; many roots; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12—9 to 18 inches, black (10YR 2/1) silty clay loam; weak, medium, subangular blocky structure parting to moderate, fine, granular; friable; common roots; few very fine and fine tubular pores; slight effervescence; moderately alkaline; gradual, smooth boundary.

A3g—18 to 23 inches, very dark gray (5Y 3/1) silty clay loam; thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure parting to moderate, fine, granular; friable; common roots; few fine and very fine tubular pores; few fine segregations and concretions of iron and manganese oxides; slight effervescence; moderately alkaline; clear, smooth boundary.

B21g—23 to 28 inches, dark-gray (5Y 4/1) silty clay loam; common, fine and medium, faint and distinct mottles of olive gray (5Y 5/2) and yellowish brown (10YR 5/6); thin, discontinuous coatings of very dark gray (5Y 3/1) on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; slight effervescence; moderately alkaline; clear, smooth boundary.

B22g—28 to 34 inches, olive-gray (5Y 5/2) silty clay loam; common, fine and medium, faint and distinct mottles of light olive gray (5Y 6/2) and yellowish brown (10YR 5/6); thin, discontinuous coatings of very dark gray (5Y 3/1) on peds in upper part; weak, fine and medium, subangular blocky structure; friable; few roots; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

B3g—34 to 41 inches, olive-gray (5Y 5/2) silty clay loam; many fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6 and 10YR 5/8); weak, medium, subangular blocky structure; friable; few roots; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; gradual, smooth boundary.

C1g—41 to 54 inches, olive-gray (5Y 5/2) heavy silt loam; many, fine and medium, distinct and faint mottles of olive brown (2.5Y 4/4), yellowish brown (10YR 5/6), and light olive gray (5Y 6/2); massive; friable; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline; abrupt, wavy boundary.

IIC2g—54 to 60 inches, mixed olive-gray (5Y 5/2) and olive-brown (2.5Y 4/4) loam; common, fine and medium, faint and distinct mottles of yellowish brown (10YR 5/6) and light olive gray (5Y 6/2); massive; friable; few fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine and medium segregation and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 30 to 48 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). The A horizon is silty clay loam or light silty clay and is 14 to 24 inches thick.

The B2 horizon ranges from dark gray (5Y 4/1) to grayish brown (10YR 5/2). The B1 horizon is silty clay loam or light silty clay, and the B3 horizon is silty clay loam or heavy silt loam. The B horizon is 14 to 30 inches thick.

The Clg horizon, if it is loess, is gray (5Y 5/1) or olive gray (5Y 5/2) and is light silty clay loam or silt loam. Depth to the glacial till IIC horizon ranges from 40 to 72 inches.

Spicer soils, like the associated Marcus and Afton soils, are poorly drained. Unlike Marcus and Afton soils, Spicer soils have a calcareous solum. They have a thinner A horizon than that of Afton soils.

32—Spicer silty clay loam, 0 to 2 percent slopes. This nearly level soil is on moderately broad flats and in narrow draws on uplands. Areas of this soil are irregular in shape and range from 4 to 20 or more acres in size.

Included with this soil in mapping are small areas of Marcus soils. Also included are areas of soils that have a surface layer more than 24 inches thick.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to row crops. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw-2; environmental planting group 2.

Spillville Series

The Spillville series consists of somewhat poorly drained soils on bottom lands and on low, concave foot slopes. These soils formed in loamy alluvium and colluvium under a native vegetation of prairie grasses. Slopes range from 0 to 5 percent.

In a representative profile the surface layer is black loam about 31 inches thick. The next layer is very dark gray loam about 14 inches thick. The underlying material is very dark gray and very dark grayish-brown loam to a depth of 68 inches and dark grayish-brown loam below.

Spillville soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is medium in the surface layer and low or medium in the underlying material. The content of available potassium generally is medium in the surface layer and low or medium in the underlying material. Reaction is neutral or slightly acid in the surface layer.

Spillville soils are used mainly for cultivated crops and pasture. The major limitations in cultivated areas are wetness and occasional flooding.

Representative profile of Spillville loam, 0 to 2 percent slopes, in a cultivated field 72 feet south and 207 feet west of the northeast corner of SE1/4 sec. 5, T. 93 N., R. 36 W.:

Ap—0 to 8 inches, black (10YR 2/1) loam; moderate, very fine and fine, granular structure; friable; many roots; common very fine and fine tubular pores; common very small pebbles; neutral; abrupt, smooth boundary.

A12—8 to 19 inches, black (10YR 2/1) loam; weak, very fine and fine, subangular blocky structure; friable; common roots; common roots; common very fine and fine tubular pores; common very small pebbles; neutral; gradual, smooth boundary.

A13—19 to 24 inches, black (10YR 2/1) heavy loam; weak, very fine and fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common very small and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A14—24 to 31 inches, black (10YR 2/1) loam; common, fine and medium, faint mottles of very dark gray (10YR 3/1); weak, very fine and fine, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common small pebbles; neutral; gradual. smooth boundary.

AC—31 to 45 inches, very dark gray (10YR 3/1) loam; thin, discontinuous coatings of black (10YR 2/1) on peds; weak, very fine and fine, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common small pebbles; neutral; clean, smooth boundary.

C1—45 to 54 inches, very dark gray (10YR 3/1) loam; very weak, very fine and fine, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; many small and medium pebbles; mildly alkaline; gradual, smooth boundary.

C2—54 to 68 inches, very dark grayish-brown (10YR 3/2) loam; common, fine and medium, faint mottles of dark brown (10 YR 3/3); thin, discontinuous coatings of very dark gray (10YR 3/1) on peds; very weak, very fine and fine, subangular blocky structure; friable; common very fine and fine tubular pores; few very small pebbles; mildly alkaline; clear, wavy boundary.

C3—68 to 80 inches, dark grayish-brown (2.5Y 4/2) loam; common, fine and medium, faint mottles of brown (10YR 4/3) and dark brown (10YR 3/3); massive; friable; common very fine and fine tubular pores; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 30 to 56 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). The A horizon is 30 to 56 inches thick. Reaction in the A horizon is neutral or slightly acid.

The C horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (2.5Y 4/2). It is loam, clay loam, or sandy loam. Reaction ranges from neutral to moderately alkaline.

Spillville soils are associated with Colo soils. They have less clay and more sand than Colo soils and have better natural drainage.

485—Spillville loam, 0 to 2 percent slopes. This nearly level soil is on bottom lands. Areas of this soil are long and narrow or irregular in shape and generally range from 5 to 30 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils that have a surface layer less than 30 inches thick. Also included are small areas of Colo soils and areas of soils that have a surface layer of clay loam.

Most areas of this soil are cultivated. Where protected from flooding, the soil is well suited to row crops. It is

susceptible to occasional damaging overflow, and it has an occasional high water table. In cultivated areas it has a moderate limitation because of wetness. Capability unit IIw–1; environmental planting group 1.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping soil is on concave foot slopes. Areas of this soil are long and narrow in shape and generally range from 4 to 16 or more acres in size.

Included with this soil in mapping are areas of soils that have a surface layer less than 30 inches thick. Also included are small areas of Colo and Terril soils and areas of soils that have a surface layer of clay loam.

Most areas of this soil are used for cultivated crops and pasture. Where runoff is controlled, the soil is well suited to row crops. It is moderately susceptible to erosion. Capability unit IIe–2; environmental planting group 1.

Storden Series

The Storden series consists of moderately sloping to very steep, somewhat excessively drained, loamy soils on the Wisconsin (Tazewell and Cary) till plains. These soils formed in calcareous glacial till under a native vegetation of prairie grasses. Slopes are convex and range from 5 to 40 percent.

In a representative profile the surface layer is very dark grayish-brown loam about 6 inches thick. The underlying material is yellowish-brown, friable loam.

Storden soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from moderately low to very low. The content of available phosphorus is very low or low in the surface layer and very low in the underlying material. The content of available potassium is low in the surface layer and very low in the underlying material. Reaction generally is alkaline in the surface layer.

Storden soils are used mainly for cultivated crops and pasture. The major limitation in cultivated areas is erosion.

Representative profile of Storden loam, 5 to 9 percent slopes, in a cultivated field 60 feet south and 1,230 feet east of the northwest corner of SW1/4 sec. 11, T. 91 N., R. 36 W.:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, few fine peds of brown (10YR 5/3) and yellowish brown (10YR 5/4); weak, fine, granular structure; friable; common roots; common fine tubular pores; common small pebbles; strong effervescence; moderately alkaline; abrupt, smooth boundary.

C1—6 to 20 inches, yellowish-brown (10YR 5/4) loam; very weak, medium, subangular blocky structure; friable; common roots; root channels filled with very dark grayish-brown (10YR 3/2) loam; common fine tubular pores; common fine and medium segregations of calcium carbonate; common small and medium pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2—20 to 30 inches, yellowish-brown (10YR 5/4) loam; massive; friable; few roots; common fine tubular pores; few fine and medium segregations of yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6), and yellowish-red (5YR 4/6) iron oxides; common fine and medium segregations of calcium carbonate; common small and medium pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C3—30 to 72 inches, yellowish-brown (10YR 5/4) loam; few, fine and medium, distinct mottles of light brownish gray (10YR 6/2); massive; friable; few roots; common fine tubular pores; few fine and medium segregations of yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6), and yellowish-red (5YR 4/6) iron oxides; common fine and medium segregations of calcium carbonate; common small and medium pebbles; strong effervescence; moderately alkaline.

Thickness of the solum generally is the same as that of the A horizon. The A horizon ranges from black (10YR 2/1) to dark brown (10YR 3/3). It is loam or light clay loam and generally is 5 to 7 inches thick. Reaction in the A horizon is mildly alkaline or moderately alkaline.

The C horizon is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4 or 5/6). Mottles range from brownish gray (10YR 6/2) to strong brown (7.5Y 5/8).

Storden soils are associated with Clarion and Everly soils, but they have a much thinner solum than those soils. Unlike Clarion and Everly soils, Storden soils have a calcareous solum.

62C—Storden loam, 5 to 9 percent slopes. This moderately sloping, calcareous soil is on convex side slopes on glacial till plains. Areas of this soil are long and narrow or irregular in shape and generally range from 4 to 10 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are small areas of Clarion, Estherville, Everly, and Salida soils.

Most areas of this soil are used for cropland and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is low to moderately low. Capability unit IIIe–1; environmental planting group 3.

62D—Storden loam, 9 to 14 percent slopes. This strongly sloping, calcareous soil is on convex side slopes on glacial till plains. Areas of this soil generally are long and narrow in shape and range from 4 to 10 or more acres in size.

Included with this soil in mapping are small areas of Clarion, Estherville, and Salida soils and areas of Everly soils.

Most areas of this soil are used for cropland and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. The content of organic matter in the surface layer is low to moderately low. Capability unit IIIe–2; environmental planting group 3.

62E—Storden loam, 14 to 18 percent slopes. This moderately steep, calcareous soil is on convex side slopes on glacial till plains. Areas of this soil generally are long and narrow in shape and range from 4 to 20 or more acres in size.

Included with this soil in mapping are small areas of Estherville soils and areas of Everly and Salida soils.

Most areas of this soil are used for pasture and cropland. The soil is moderately well suited to row crops. It is very highly susceptible to erosion. The content of organic matter in the surface layer is low. Capability unit IVe–1; environmental planting group 3.

62F—Storden loam, 18 to 25 percent slopes. This steep, calcareous soil is on convex side slopes on glacial till plains. Areas of this soil are long and narrow in shape and range from 10 to 50 or more acres in size.

Included with this soil in mapping are small areas of Lester and Salida soils and areas of Everly soils.

Most areas of this soil are in pasture. The soil is poorly suited to row crops. It is very highly susceptible to erosion. The content of organic matter in the surface layer is very low or low. Capability unit VIe–1; environmental planting group 3.

62G—Storden loam, 25 to 40 percent slopes. This very steep, calcareous soil is on convex side slopes on glacial till plains. Areas of this soil are long and narrow in shape and range from 10 to 50 or more acres in size.

Included with this soil in mapping are areas of Everly, Lester, and Salida soils.

Most areas of this soil are in pasture. The soil is not suited

to row crops. It is very highly susceptible to erosion. The content of organic matter in the surface layer is very low or low. Capability unit VIIe–1; environmental planting group 3.

Talcot Series

The Talcot series consists of calcareous, very poorly drained soils on low-lying flats in glacial outwash areas on stream terraces. These soils formed in moderately fine textured glacial outwash underlain by sand and gravel at a depth of 24 to 40 inches. The native vegetation was swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 18 inches thick. It is black clay loam in the upper part and very dark gray clay loam in the lower part. The subsoil extends to a depth of 38 inches. It is very dark gray, friable clay loam in the upper part, olive-gray and light olive-gray, friable clay loam and loam in the middle part, and light olive-gray, very friable sandy loam in the lower part. The substratum is mixed light olive-gray and olive-gray gravelly sand.

Talcot soils have moderate permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. They have moderate or low available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus is very low in both the surface layer and the subsoil. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. Reaction is moderately alkaline in the surface layer.

Talcot soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness. Also, the soils do not supply enough available water in dry years, especially those that are less than 32 inches deep to sand and gravel.

Representative profile of Talcot clay loam, deep, 0 to 2 percent slopes, in a cultivated field 330 feet north and 480 feet west of the southeast corner of NE1/4 sec. 34, T. 91 N., R. 37 W.:

Ap—0 to 9 inches, black (N 2/0) clay loam; moderate, fine and medium, granular structure; friable; many roots; few fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; abrupt, smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) clay loam; common, discontinuous, black (N 2/0) coatings on peds; weak, fine, subangular blocky structure parting to weak, fine, granular; friable; common roots; common very fine and fine tubular pores; few fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

A13—13 to 18 inches, very dark gray (10YR 3/1) clay loam; common, fine, dark olive-gray (5Y 3/2) peds; discontinuous black (N 2/0) coatings on peds; weak, fine and medium, subangular blocky structure parting to weak, fine, granular; friable; common roots; common very fine and fine tubular pores; few fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

Blg—18 to 22 inches, very dark gray (5Y 3/1) light clay loam; common, fine and medium, faint mottles of olive gray (5Y 4/2) and 5Y 5/2); thin, discontinuous coatings of black (10YR 2/1) on peds; weak, fine, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

B21g—22 to 28 inches, olive-gray (5Y 5/2) clay loam; dark gray (5Y 4/1) coatings on a few faces of peds; common, fine, faint mottles of olive gray (5Y 4/2); weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, smooth boundary.

B22g—28 to 36 inches, light olive-gray (5Y 5/2) loam; common, fine, faint mottles of olive gray (5Y 5/2); weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; gradual, wavy boundary.

B3g—36 to 38 inches, light olive-gray (5Y 6/2) sandy loam; common, fine, faint mottles of olive (5Y 5/4); very weak, medium, subangular blocky structure; very friable; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of iron and manganese oxides; common fine segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; clear, wavy boundary.

IICg—38 to 60 inches, mixed light olive-gray (5Y 6/2) and olive-gray (5Y 5/2) gravelly sand; single grained; loose; common fine segregations and concretions of calcium carbonate; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 40 inches. The A1 horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is clay loam or loam. The A horizon is 14 to 22 inches thick. Reaction in the A horizon is mildly alkaline or moderately alkaline.

The B2 horizon ranges from dark gray (2.5Y 4/1 or 5Y 4/1) to olive gray (5Y 5/2). The B horizon is clay loam, loam, or sandy clay loam. In some areas layers of thin gravelly loam, sandy loam, or gravelly sandy loam are in the lower part of the B horizon. Depth to sand and gravel ranges from 24 to 40 inches.

The IIC horizon generally is sand and gravel, gravelly sand, or sand. In places the IIC1 horizon is loamy sand or gravelly loamy sand.

Talcot soils, like the associated Biscay and Cylinder soils, are underlain by sand and gravel. Unlike Biscay and Cylinder soils, Talcot soils have a calcareous solum. This B horizon is grayer than that of Cylinder soils. Talcot and Canisteo soils are both calcareous throughout. Unlike the Canisteo soils, Talcot soils are underlain by sand and gravel.

559—Talcot clay loam, deep, 0 to 2 percent slopes. This nearly level, calcareous soil is in glacial outwash areas and on stream terraces. It has sand and gravel at a depth of 32 to 40 inches. Areas are irregular in shape and generally range from 20 to 40 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are areas of soils in which depth to sand and gravel is less than 32 inches and areas of soils in which that depth is more than 40 inches. Also included are small areas of Biscay and Okoboji soils and small areas of soils that have a highly calcareous surface layer.

Most areas of this soil are cultivated. In these areas this Talcot soil has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. In places it does not have enough water available for the best growth of crops in very dry years. Capability unit IIw–3; environmental planting group 2.

558—Talcot clay loam, moderately deep, 0 to 2 percent slopes. This nearly level, calcareous soil is in glacial outwash areas and on stream terraces. It has sand and gravel at a depth of 24 to 32 inches. Areas are irregular in shape and generally range from 4 to 20 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but depth to sand and gravel is less than it is in that soil. Included in mapping are areas of soils in which depth to sand and gravel is more than 32 inches. Also included are small areas of Biscay and Okoboji soils and small areas of soils that have a highly calcareous surface layer.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to row crops. It has a seasonal high water table. The soil has low or moderate available water capacity and does not have enough water available for the best growth of crops in some years. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation because of wetness where it is not artificially drained. Capability unit IIw-3; environmental planting group 2.

Terril Series

The Terril series consists of moderately well drained soils on nearly plane to slightly concave foot slopes below narrow, steep breaks. These soils formed in loamy sediment derived from glacial till. The native vegetation was mainly prairie grasses. Slopes range from 4 to 9 percent.

In a representative profile the surface layer is about 32 inches thick. It is black loam in the upper part, black clay loam in the middle part, and very dark grayish-brown light clay loam in the lower part. The subsoil extends to a depth of 60 inches. It is dark-brown, friable loam in the upper part and brown, friable silt loam in the lower part.

Terril soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is medium in the surface layer and very low in the subsoil. The content of available potassium is low or medium in the surface layer and very low or low in the subsoil. Unless these soils are limed, reaction generally is slightly acid in the surface layer.

Terril soils are used mainly for cultivated crops and pasture. Erosion is the major limitation in cultivated areas and pasture.

Representative profile of Terril loam, 4 to 9 percent slopes, in a permanent pasture 1,330 feet north and 220 feet east of the southwest corner of sec. 4, T. 93 N., R. 36 W.:

A11—0 to 8 inches, black (10YR 2/1) loam; moderate, very fine and fine, granular structure; friable; many roots; common small pebbles; neutral; gradual, smooth boundary.

A12—8 to 15 inches, black (10YR 2/1) light clay loam; weak, very fine and fine, subangular blocky structure; friable; common roots; few very fine and fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A13—15 to 24 inches, very dark grayish-brown (10YR 3/2) light clay loam; discontinuous black (10YR 2/1) coatings on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; clear, smooth boundary.

A3—24 to 32 inches, very dark grayish-brown (10YR 3/2) light clay loam; common, fine, faint mottles of dark brown (10YR 3/3); weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; clear, smooth boundary.

B21—32 to 42 inches, dark-brown (10YR 3/3) loam; discontinuous coatings of very dark grayish brown (10YR 3/2) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; common small pebbles; neutral; clear, smooth boundary.

B22—42 to 50 inches, dark-brown (10YR 3/3) loam; common, fine, faint mottles of brown (10YR 4/3); thin, discontinuous coatings of very dark grayish brown (10YR 3/2) on peds; weak, fine and medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common small pebbles; neutral; clear, smooth boundary.

B3—50 to 60 inches, brown (10YR 4/3) silt loam; thin, discontinuous coatings of dark brown (10YR 3/3) on peds; weak, medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common small pebbles; neutral.

Thickness of the A horizon ranges from 24 to 36 inches. Texture is loam or light clay loam. Reaction in the A horizon is slightly acid or neutral. The A1 horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The A3 horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2).

The B horizon is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3). It is loam, light clay loam, or silt loam. Reaction is slightly acid or neutral.

Terril soils, like Spillville and Colo soils, formed in colluvium or alluvium. Terril soils are browner within a depth of 36 inches than Spillville soils. They contain less clay and more sand than Colo soils and are better drained than those soils.

27C—Terril loam, 4 to 9 percent slopes. This moderately sloping soil is on nearly plane to slightly concave foot slopes. Areas of this soil are long and narrow and generally range from 4 to 20 or more acres in size.

Included with this soil in mapping are small areas of Spillville and Storden soils. Also included are small areas of Terril soils that have slopes of less than 4 percent or more than 9 percent.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. Capability unit IIIe-1; environmental planting group 1.

Wacousta Series

The Wacousta series consists of very poorly drained soils in shallow glacial lake basins. These soils formed in silty, water-worked glacial sediment or local alluvium under a native vegetation of swamp grasses and sedges. Slopes range from 0 to 1 percent.

In a representative profile the surface layer is about 15 inches thick. It is black mucky silt loam in the upper part and black silty clay loam in the lower part. The underlying material is olive-gray silt loam to a depth of 24 inches and gray silt and silty clay loam below.

Wacousta soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is very high. The content of available phosphorus generally is very low or low in the surface layer and very low in the underlying material. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. Reaction is neutral or slightly acid in the surface layer.

Wacousta soils are used mainly for cultivated crops. The major limitations in cultivated areas are wetness and ponding.

Representative profile of Wacousta mucky silt loam, 0 to 1 percent slopes, in a cultivated field 475 feet south and 30 feet west of the northeast corner of sec. 27, T. 93 N., R. 37 W.:

Ap—0 to 7 inches, black (N 2/0) mucky silt loam; weak, medium, subangular blocky structure parting to moderate, fine and medium, granular; friable; many roots; neutral; abrupt, smooth boundary.

A12—7 to 15 inches, black (N 2/0) light silty clay loam; weak, fine and medium, subangular blocky structure; friable; common roots; common very fine and fine tubular pores; neutral; abrupt, wavy boundary.

Clg—15 to 24 inches, olive-gray (5Y 5/2) silt loam; many, medium and coarse, distinct mottles of dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), strong brown (7.5YR 5/6), and light olive gray (5Y 6/2); discontinuous coatings of black (10YR 2/1 and N 2/0) on peds; weak, medium, subangular blocky structure; friable; few roots; common very fine and fine tubular pores; common fine root channels filled with black (10YR 2/1 and N 2/0) silty clay loam; common fine segregations of iron and manganese oxides; few very fine segregations of calcium carbonate; slight effervescence; moderately alkaline; gradual, wavy boundary.

C3g—24 to 30 inches, gray (5Y 5/1) silt loam; many, medium, distinct mottles of dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), grayish brown (10YR 5/2), strong brown (7.5YR 5/6), and light olive gray (5Y 6/2); discontinuous black (10YR 2/1 and N 2/0) coatings on peds; massive; friable; few roots; common fine tubular pores; common fine root channels filled with black (10YR 2/1 and N 2/0) silty clay loam; common fine segregations of iron and manganese oxides; few very fine segregations of calcium carbonate; slight effervescence; moderately alkaline; gradual, smooth boundary.

C3g—30 to 50 inches, gray (5Y 5/1) light silty clay loam; common, fine and medium, distinct mottles of dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), strong brown (7.5YR 5/6), light gray (5Y 7/2), and light olive gray (5Y 6/2); weak, fine, subangular blocky structure; friable; common fine tubular pores; common fine and medium segregations of iron and manganese oxides; common fine segregations of calcium carbonate; slight effervescence; moderately alkaline; gradual, smooth boundary.

C4g—50 to 60 inches, gray (5Y 5/1) heavy silt loam; common, medium, distinct mottles of dark yellowish brown (10YR 4/4), strong brown (7.5YR 5/6), and light olive brown (2.5Y 5/4); massive; friable; few fine tubular pores; common fine and medium segregations of iron and manganese oxides; common fine segregations of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 10 to 24 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). The A horizon is dominantly mucky silt loam or mucky silty clay loam, but in places it is silty clay loam or silt loam. It is 8 to 18 inches thick. Reaction in the A horizon is neutral or slightly acid.

The Bg horizon, if present, ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2). It is silty clay loam or heavy silt loam. Reaction in the Bg horizon is neutral or mildly alkaline.

The Cg horizon ranges from gray (5Y 5/1) to light olive gray (5Y 6/2). It is silt loam or light silty clay loam. Reaction in the Cg horizon is mildly alkaline or moderately alkaline.

Wacousta soils, like the Blue Earth and Okoboji soils, are in depressions. Wacousta soils have a thinner A horizon than Blue Earth and Okoboji soils. Unlike Blue Earth soils, Wacousta soils have a noncalcareous solum. They contain less clay than Okoboji soils.

506—Wacousta mucky silt loam, 0 to 1 percent slopes. This depressional soil is in small, shallow glacial lake basins. Areas of this soil are irregular in shape and generally range from 4 to 10 or more acres in size.

Included with this soil in mapping are small areas of Okoboji and Blue Earth soils.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is moderately well suited to row crops. It is highly susceptible to ponding on the surface and generally has a high water table. In cultivated areas it has a severe limitation because of wetness. Capability unit IIIw–2; environmental planting group 2.

Wadena Series

The Wadena series consists of nearly level to moderately sloping, well-drained soils on outwash plains, stream terraces, and kames in glacial moraines. These soils formed in loamy glacial outwash underlain by calcareous sand and gravel at a depth of 24 to 40 inches. The native vegetation was prairie grasses. Slopes range from 0 to 9 percent.

In a representative profile the surface layer is about 14 inches thick. It is black loam in the upper part and very dark grayish-brown loam in the lower part. The subsoil extends to a depth of 28 inches. It is brown, friable loam in the upper part and dark yellowish-brown, friable sandy clay loam in the lower part. The substratum is yellowish-brown gravelly sand to a depth of 38 inches and yellowish-brown sand and gravel below.

Wadena soils have moderately rapid permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. They have moderate or low available water capacity where sand and gravel are at a depth of 24 to 32 inches and moderate available water capacity where sand and gravel are at a depth of 32 to 40 inches. The content of organic matter in the surface layer is high to moderately low. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is very low or low in both the surface layer and the subsoil. Unless these soils are limed, reaction generally is slightly acid in the surface layer.

Wadena soils are used mainly for cultivated crops and pasture. The major limitations in cultivated areas are their limited available water capacity and erosion.

Representative profile of Wadena loam, moderately deep, 2 to 5 percent slopes, in a cultivated field 30 feet north and 1,040 feet west of the southeast corner of NE1/4 sec. 34, T. 91 N., R. 37 W.:

Ap—0 to 10 inches, black (10YR 2/1) loam; weak, fine and medium, granular structure; friable; many roots; common fine tubular pores; common small pebbles; slightly acid; abrupt, smooth boundary.

A3—10 to 14 inches, very dark grayish-brown (10YR 3/2) loam; common peds of dark brown (10YR 3/3) and brown (10YR 4/3); common discontinuous coatings of black (10YR 2/1) on peds; weak, fine, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B21—14 to 18 inches, brown (10YR 4/3) loam; common discontinuous coatings of very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), and black (10YR 2/1) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B22—18 to 24 inches, brown (10YR 4/3) loam; common peds of dark yellowish brown (10YR 4/4) and brown (7.5YR 4/4); thin, discontinuous coatings of dark brown (10YR 3/3) on peds; weak, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B3—24 to 28 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; common peds of brown (10YR 4/3 and 7.5YR 4/4); thin, discontinuous coatings of very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) on peds; weak, medium, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; clear, wavy boundary.

IIC1—28 to 38 inches, yellowish-brown (10YR 5/4) gravelly sand; single grained; loose; few roots; slight effervescence; mildly alkaline; gradual, wavy boundary.

IIC2—38 to 60 inches, yellowish-brown (10YR 5/4) sand and gravel; single grained; loose; slight effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 40 inches. The A1 horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). It is loam or light clay loam. The A horizon is 12 to 20 inches thick. Reaction in the A horizon is slightly acid or neutral.

The B2 horizon ranges from dark brown (10YR 3/3) to yellowish brown (10YR 5/4). It is loam or light clay loam. Reaction in the B2 horizon is slightly acid or neutral. The B3 horizon is loam to sandy loam.

The IIC horizon ranges from dark grayish brown (10YR 4/2) to yellowish brown (10YR 5/4). It is sand, gravelly sand, or sand and gravel. Reaction in the IIC horizon generally is mildly alkaline or moderately alkaline.

Wadena soils, like the associated Cylinder and Estherville soils, are underlain by sand and gravel. They have a browner B horizon than that of Cylinder soils, and they generally have a thinner A horizon. Wadena soils have more clay in the solum than Estherville soils, and they generally have a thicker solum.

308B—Wadena loam, deep, 1 to 5 percent slopes. This gently sloping soil in on convex ridges in glacial outwash areas, on stream terraces, and on kames in glacial moraines.

Areas of this soil are irregular in shape and range from 4 to 20 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but depth to sand and gravel is 32 to 40 inches. Included in mapping are small areas of soils in which depth to sand and gravel is more than 40 inches.

Most areas of this soil are cultivated. The soil is well suited to row crops. It is moderately susceptible to erosion. It does not have enough water available for the best growth of crops in dry years. The content of organic matter in the surface layer is moderate. Capability unit IIe–1; environmental planting group 1.

108—Wadena loam, moderately deep, 0 to 2 percent slopes. This nearly level soil is on stream terraces and in glacial outwash areas. Areas of this soil are irregular in shape and range from 4 to 40 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thicker. Included in mapping are small areas of soils in which depth to sand and gravel is less than 24 inches and small areas of soils in which that depth is more than 32 inches. Also included are small areas of Cylinder soils.

Most areas of this soil are used for cultivated crops and pasture. The soil is well suited to row crops. It has low or moderate available water capacity, however, and does not have enough water available for satisfactory growth of crops in many years. The content of organic matter in the surface layer is high or moderate. Capability unit IIs–1; environmental planting group 1.

108B—Wadena loam, moderately deep, 2 to 5 percent slopes. This gently sloping soil is on convex ridges in glacial outwash areas, on stream terraces, and on kames in glacial moraines. Areas of this soil are irregular in shape and generally range from 4 to 50 or more acres in size.

This soil has the profile described as representative of the series. Included in mapping are small areas of Estherville, Salida, and Storden soils. Also included are small areas of soils in which depth to sand and gravel is less than 24 inches and small areas of soils in which that depth is more than 32 inches.

Most areas of this soil are used for cultivated crops and pasture. Where erosion is controlled, the soil is well suited to row crops. It is susceptible to erosion. It has low or moderate available water capacity and does not have enough water available for satisfactory growth of crops in many years. The content of organic matter in the surface layer is moderate. Capability unit IIe–3; environmental planting group 1.

108C2—Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on convex slopes in glacial outwash areas, on stream terraces, and on kames in glacial moraines. Areas of this soil are long and narrow or irregular in shape and range from 4 to 20 or more acres in size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. Included in mapping are small areas of Dickinson, Salida, and Estherville soils and small areas of soils in which depth to sand and gravel is less than 24 inches or more than 32 inches. Also included are small areas of soils that have slopes of more than 9 percent.

Most areas of this soil are used for cultivated crops and pasture. The soil is moderately well suited to row crops. It is highly susceptible to erosion. It has low or moderate available water capacity and does not have enough water available for satisfactory growth of crops in many years. The content of organic matter in the surface layer is moderately low. Capability unit IIIe–3; environmental planting group 1.

Waldorf Series

The Waldorf series consists of poorly drained soils on low-lying ground moraines of the Wisconsin (Cary) till plain. These soils formed in fine-textured lacustrine sediment under a native vegetation of swamp grasses and sedges and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 16 inches thick. The subsoil of firm silty clay extends to a depth of 42 inches. It is dark gray in the upper part and olive gray in the lower part. The substratum is olive-gray silty clay.

Waldorf soils have moderately slow permeability and moderate available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

Waldorf soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Waldorf silty clay loam, 0 to 2 percent slopes, in a cultivated field 390 feet south and 369 feet east of the northwest corner of sec. 16, T. 93 N., R. 37 W.:

Ap—0 to 8 inches, black (N 2/0) heavy silty clay loam; cloddy parting to weak, fine and medium, granular structure; friable; many roots; neutral; abrupt, smooth boundary.

A1—8 to 16 inches, black (10YR 2/1) heavy silty clay loam; common, fine and medium, faint mottles of very dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure and weak, fine, granular; firm; common roots; few fine tubular pores; few very fine segregations of yellowish-brown (10YR 5/6) oxides; neutral; gradual, smooth boundary.

B1g—16 to 24 inches, dark-gray (5Y 4/1) silty clay; many, fine and medium, faint mottles of very dark grayish brown (10YR 3/2) and common, very fine, distinct mottles of strong brown (7.5YR 5/6 and 7.5YR 5/8); common very dark gray (10YR 3/1) coatings on peds; weak, medium, prismatic structure parting to moderate, very fine and fine, subangular blocky; firm; common roots; few fine tubular pores; distinct sheen on peds; few fine segregations of strong-brown (7.5YR 5/6) and very dark brown (10YR 2/2) iron and manganese oxides; neutral; gradual, smooth boundary.

B2g—24 to 36 inches, olive-gray (5Y 4/2) silty clay; common dark-gray (10YR 4/1) coatings and thin, discontinuous, very dark gray (10YR 3/1) coatings on peds; weak, medium, prismatic structure parting to weak, very fine and fine, subangular blocky; firm; common roots; few fine tubular pores; few slickensides; very distinct sheen on peds; few, fine, yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6), and very dark brown (10YR 2/2) segregations and concretions of oxides; mildly alkaline; gradual, wavy boundary.

B3g—36 to 42 inches, olive-gray (5Y 4/2) silty clay; common, fine and medium, faint mottles of light olive gray (5Y 6/2) and dark gray (10YR 4/1); weak, medium, subangular blocky structure; firm; few roots; few fine tubular pores; distinct slickensides; distinct sheen on peds; common, fine, strong-brown (7.5YR 5/6) and very dark brown (10YR 2/2) segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; few fine crystals, presumably gypsum; strong effervescence; moderately alkaline; gradual, smooth boundary.

Cg—42 to 62 inches, olive-gray (5Y 5/2) silty clay; common, fine and medium, faint mottles of light olive gray (5Y 6/2), olive gray (5Y 4/2), and olive (5Y 5/4); massive; friable; few fine tubular

pores; common, fine, strong-brown (7.5YR 5/6) and very dark brown (10YR 2/2) segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 26 to 48 inches. The Ap horizon is black (N 2/0 or 10YR 2/1). The A3 horizon, if present, is very dark gray (10YR 3/1, 5Y 3/1, or N 3/0) or dark gray (5Y 4/1). The A horizon is silty clay loam or silty clay and is 14 to 24 inches thick. Reaction in the A horizon is slightly acid or neutral.

The B2g horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 4/2 or 5Y 5/2) to grayish brown (2.5Y 5/2). It is silty clay or clay. Reaction in the B2g horizon ranges from slightly acid to mildly alkaline.

The Cg horizon ranges from gray (5Y 5/1) to olive gray (5Y 5/2 or 5Y 4/2) to dark grayish brown (2.5Y 4/2). The C horizon, above a depth of 40 inches, is silty clay, heavy silty clay loam, or heavy clay loam. Reaction in the Cg horizon is mildly alkaline or moderately alkaline.

Waldorf soils are associated with Collinwood and Webster soils. Their B horizon is grayer than that of Collinwood soils. Waldorf soils contain more clay than Webster soils.

390—Waldorf silty clay loam, 0 to 2 percent slopes. This nearly level soil is on low-lying, clayey-mantled ground moraines on uplands. Areas of this soil are irregular in shape and range from 4 to 50 or more acres in size.

Included with this soil in mapping are small areas of Collinwood and Webster soils. Also included are small areas of soils that have a calcareous surface layer.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to row crops. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw–5; environmental planting group 2.

Webster Series

The Webster series consists of poorly drained soils on low-lying flats of the undulating Wisconsin (Cary) till plain. These soils formed in glacial till or water-worked sediment under a native vegetation of swamp grasses, sedges, and prairie grasses that tolerate wetness. Slopes range from 0 to 2 percent.

In a representative profile the surface layer is about 18 inches thick. It is black silty clay loam in the upper part and black clay loam in the lower part. The subsoil of friable clay loam and loam extends to a depth of 36 inches. It is very dark gray in the upper part and dark gray in the lower part. The substratum is light brownish-gray loam.

Webster soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium is very low to medium in the surface layer and is very low or low in the subsoil. Reaction generally is neutral in the surface layer.

Webster soils are used mainly for cultivated crops. The major limitation in cultivated areas is wetness.

Representative profile of Webster silty clay loam, 0 to 2 percent slopes, in a cultivated field 54 feet north and 2,292 feet west of the southeast corner of NE1/4 sec. 1, T. 91 N., R. 37 W.:

Ap—0 to 9 inches, black (N 2/0) silty clay loam; moderate, fine and medium, granular structure; friable; common roots; few fine tubular pores; common small pebbles; neutral; abrupt, smooth boundary.

A12—9 to 14 inches, black (N 2/0) clay loam; weak, fine, subangular blocky structure parting to moderate, fine and medium, granular; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

A3—14 to 18 inches, black (10YR 2/1) clay loam; few, fine, faint mottles of very dark grayish brown (2.5Y 3/2); discontinuous black (N 2/0) coatings on peds; moderate, very fine and fine, subangular blocky structure; friable; common roots; common fine tubular pores; common small pebbles; neutral; gradual, smooth boundary.

B1g—18 to 22 inches, very dark gray (10YR 3/1) clay loam; common, fine, faint mottles of very dark grayish brown (2.5Y 3/2); thin, discontinuous coatings of black (N 2/0 and 10YR 2/1) on peds; moderate, fine and medium, subangular blocky structure; friable; common roots; common fine tubular pores; few fine segregations and concretions of iron and manganese oxides; common small pebbles; neutral; gradual, smooth boundary.

B2g—22 to 28 inches, dark-gray (2.5Y 4/1) loam; common, fine, faint mottles of dark grayish brown (2.5Y 4/2); thin, discontinuous, black (10YR 2/1) and very dark gray (10YR 3/1) coatings on peds; moderate, fine and medium, subangular blocky structure; friable; common fine tubular pores; common fine segregations and concretions of iron and manganese oxides; common small pebbles; neutral; clear, wavy boundary.

B3g—28 to 36 inches, dark-gray (2.5Y 4/1) loam; common, fine, faint mottles of dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2); thin, discontinuous coatings of very dark gray (10YR 3/1) and black (10YR 2/1) on peds; moderate, fine and medium, subangular blocky structure; friable; few roots; common fine tubular pores; common fine segregations and concretions and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; slight effervescence; moderately alkaline; clear, smooth boundary.

C1g—36 to 46 inches, light brownish-gray (2.5Y 6/2) loam; common, fine, distinct mottles of dark grayish brown (2.5Y 4/2), light olive brown (2.5Y 5/4), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6); weak, fine and medium, subangular blocky structure; friable; few roots; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline; gradual, smooth boundary.

C2g—46 to 60 inches, light brownish-gray (2.5Y 6/2) loam; common, fine, distinct mottles of olive brown (2.5Y 4/4), yellowish brown (10YR 5/6), and strong brown (7.5YR 5/6); massive; friable; common fine tubular pores; common fine and medium segregations and concretions of iron and manganese oxides; common fine and medium segregations and concretions of calcium carbonate; common small pebbles; strong effervescence; moderately alkaline.

Thickness of the solum ranges from 24 to 50 inches. The A1 horizon is black (N 2/0 or 10YR 2/1). It is silty clay loam or clay loam. The A horizon is 14 to 24 inches thick. Reaction in the A horizon is neutral or slightly acid.

The B2g horizon ranges from dark gray (2.5Y 4/1) to olive gray (5Y 5/2) and is loam or clay loam. Reaction is neutral or mildly alkaline.

The Cg horizon ranges from dark gray (2.5Y 4/1) to light olive gray (5Y 6/2) to light brownish gray (2.5Y 6/2). It generally is clay loam or loam. Reaction in the Cg horizon is mildy alkaline or moderately alkaline.

Webster soils are associated with the very poorly drained Okoboji and the poorly drained Canisteo soils. Unlike Canisteo soils, Webster soils have a noncalcareous solum. Webster soils have a thinner A horizon and contain less clay than Okoboji soils.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level soil is on low-lying glacial till plains. Areas of this soil are irregular in shape and generally range from 4 to 100 or more acres in size.

Included with this soil in mapping are small areas of Biscay, Canisteo, Harps, and Okoboji soils.

Most areas of this soil are cultivated. Where drainage is adequate, the soil is well suited to corn, soybeans, small grain, and alfalfa. It has a seasonal high water table. In cultivated areas it has a moderate limitation because of wetness where it is artificially drained and a severe limitation where it is not artificially drained. Capability unit IIw–2; environmental planting group 2.

Use and Management of the Soils

This section is designed to help the landowner understand how soils behave and how they can be used. In it are discussed the use and management of soils for crops and pasture, for wildlife and recreation, for environmental plantings, and for engineering.

Use of the Soils for Crops and Pasture

The soils in Buena Vista County are used mainly for corn, soybeans, oats, hay, and pasture. More than 90 percent of the county is cultivated.

The main considerations in managing cultivated soils in the county are controlling erosion, improving drainage, conserving moisture, and maintaining fertility.

Among the measures that help to control erosion are terracing, contour farming, diversions, waterways, and minimum tillage. Fall plowing of the soils subjects them to soil blowing, but this hazard can be reduced by various types of conservation tillage such as leaving a roughly plowed surface with alternating plowed and unplowed strips, or chisel plowing, which leaves crop residue on the surface.

Among the measures that help to improve drainage are tile drainage, open inlets, and surface drains.

Among the measures that help to conserve moisture are terracing, contour farming, and minimum tillage operations that leave crop residue on the surface. Any measure that reduces runoff generally increases infiltration and consequently conserves moisture.

Among the measures that help to maintain fertility are the application of chemical fertilizer, green manure, and barnyard manure, and the inclusion in the cropping system of cover crops, grasses, and legumes.

Tilth can be maintained by returning all crop residue, but an occasional year of meadow improves both tilth and fertility and helps to control weeds and insects.

Applications of fertilizer generally are beneficial on all crops, but the lime and fertilizer requirements of these soils vary considerably. Up-to-date information on soil testing and application of fertilizer can be obtained from the Soil Conservation Service or the Agriculture Extension Service.

This section has three main parts. In the first part the capability grouping of soils is explained. In the second part the soils are placed in capability units, and the use and management of these soils are discussed. In the third part predicted yields of principal crops under a high level of management are given for each soil.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for woodland, or for engineering.

In the capability system (*9*), the kinds of soils are grouped at three levels; the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, and water supply or to esthetic purposes. (None in Buena Vista County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIw-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass; or kind of limitation, as defined in the foregoing paragraph; and the

Arabic numeral specifically identifies the capability unit within each subclass.

In the following paragraphs the capability units in Buena Vista County are described and suggestions for the use and management of the soils are given.

Management by capability units

The capability units, or groups of soils that have similar management requirements, are described in the following paragraphs. Certain limitations of the soils are given in these descriptions, and suitable management is briefly discussed. To find the names of all soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of the survey. The groupings of soils shown in this guide are subject to change as new methods are discovered or new information becomes available.

CAPABILITY UNIT I-1

This unit consists of deep, nearly level, well-drained and somewhat poorly drained soils of the Galva, Nicollet, and Primghar series. The surface layer is loam or silty clay loam, and the subsoil also is loam or silty clay loam. Slopes range from 0 to 3 percent.

These soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium is medium or high in the surface layer of the Galva and Primghar soils, but it is low or medium in the surface layer of the Nicollet soils. The content of available potassium is very low or low in the subsoil of all of the soils in this unit. Reaction ranges from medium acid to neutral in the surface layer.

The soils of this unit are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. Lime is needed on some of these soils. All the soils in this unit are friable and easy to work.

Row crops can be grown on these soils much of the time. Tile drainage is beneficial to some soils in relatively low positions. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. Such conservation practices as minimum tillage, contour farming, or both, are desirable in places on long slopes. An occasional year of meadow improves tilth and helps to control weeds and insects. Fall plowing subjects the soils to soil blowing, but a roughly plowed surface with alternating plowed and unplowed strips reduces the hazard. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces the hazard of soil blowing.

CAPABILITY UNIT I-2

Cylinder loam, deep, 0 to 2 percent slopes, is the only soil in this capability unit. This nearly level, somewhat poorly drained soil is in glacial outwash areas and on stream terraces. The surface layer and the subsoil are loam. The substratum is sand and gravel at a depth of 32 to 40 inches.

This soil has moderate permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. It has moderate available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to row crops. Lime is needed in places. This soil is friable and easy to work. In dry years it is somewhat more susceptible to droughtiness than the soils in capability unit I-1.

Row crops can be grown on this soil much of the time. Fall plowing subjects the soil to soil blowing, but a roughly plowed surface with alternating plowed and unplowed strips reduces the hazard. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces the hazard of soil blowing. An occasional year of meadow improves tilth and helps to control weeds and insects. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas.

CAPABILITY UNIT IIe-1

This unit consists of deep, gently sloping, well-drained soils of the Clarion, Everly, Galva, Sac, and Wadena series. The surface layer and the subsoil are loam, clay loam, or silty clay loam. Slopes range from 1 to 5 percent.

All but the Wadena soils in this unit have moderate or slow permeability and high available water capacity. Wadena soils have moderately rapid permeability and moderate available water capacity. The content of organic matter in the surface layer is moderate or high in soils of this unit. The content of available phosphorus generally is very low or low in the surface layer and subsoil. The content of available potassium is low or medium in the surface layer of the Clarion and Wadena soils and is medium or high in the surface layer of the Everly, Galva, and Sac soils. The content of available potassium is very low or low in the subsoil of all of these soils. Reaction ranges from medium acid to neutral in the surface layer.

The soils in this unit are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. Lime is needed on many of these soils. These soils are friable and easy to work, but they are moderately susceptible to erosion.

CAPABILITY UNIT IIe-2

This unit consists of deep, gently sloping soils of the Ely, Primghar, and Spillville series. These soils have a surface layer and subsoil of silty clay loam or loam. Slopes range from 2 to 5 percent.

All of these soils have moderate or moderately slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low to medium in the surface layer and in the subsoil. The content of available potassium is medium or high in the surface layer and is very low to medium in the subsoil. Reaction ranges from medium acid to neutral in the surface layer.

The soils in this unit are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. Row crops can be grown much of the time if erosion is controlled. Lime is needed in places. These soils are friable and easy to work, but they are subject to runoff from adjacent slopes and are moderately susceptible to erosion.

Such conservation practices as terracing, contour farming, and minimum tillage help to control erosion. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. Diversion terraces constructed above these soils will protect them against sil-

tation and runoff. Interceptor tile is needed in places to remove seepage water and to allow more timely field operations.

CAPABILITY UNIT IIe-3

Wadena loam, moderately deep, 2 to 5 percent slopes, is the only soil in this capability unit. This gently sloping to gently undulating, well-drained soil is on convex ridges in glacial outwash areas and on stream terraces. The surface layer and subsoil are loam. The soil has sand and gravel at a depth of 24 to 32 inches.

This soil has moderately rapid permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. It has moderate or low available water capacity. The content of organic matter in the surface layer is moderate. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is very low or low in both the surface layer and the subsoil. Unless this soil is limed, reaction is medium acid or slightly acid in the surface layer.

This soil is used mainly for cultivated crops and pasture. It is well suited to row crops, and row crops can be grown much of the time if erosion is controlled. Lime generally is needed periodically. This soil warms early in spring, and it can be tilled soon after rains. It is friable and easy to work, but it is moderately susceptible to both droughtiness and erosion.

Such conservation practices as terracing, contour farming, and minimum tillage help to control erosion and conserve moisture. An occasional year of meadow improves tilth and helps to control weeds and insects. In building terraces, deep cuts should be avoided because the sandy or gravelly underlying material has very low available water capacity.

CAPABILITY UNIT IIe-4

Collinwood silty clay loam, 2 to 5 percent slopes, is the only soil in this capability unit. This somewhat poorly drained soil has convex, gentle slopes. It is on glacial till uplands. The surface layer is silty clay loam, and the subsoil is silty clay.

This soil has slow permeability and high available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and is very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to row crops, and they can be grown much of the time if erosion is controlled. Lime is needed in places. This soil has a clayey subsoil. It tends to warm somewhat more slowly in spring than the soils in capability unit IIe-1, and it dries more slowly after rains. The soil is fairly easy to work, but if it is worked when wet, it is likely to become hard and cloddy when dry. This soil is moderately susceptible to erosion.

Such conservation practices as terracing, contour farming, and minimum tillage help to control erosion. Although water is excessive in a few places during wet periods, tile drains are seldom used. Tilth can be maintained on this soil by returning all crop residue, and an occasional year of meadow improves tilth and helps control weeds and insects. Terraces are used in places to control erosion, but the many cuts required to build the terraces sometimes expose the clayey subsoil, which has poor fertility and poor tilth. Fertility and tilth generally can be only partly restored by spreading a layer of topsoil and large amounts of manure and crop residue over the cuts. Terraces help to conserve moisture in dry years, but in places they cause this slowly permeable soil to need tile drainage in the terrace channels in wet years. Because terraces have drawbacks on this slowly permeable soil, other erosion-control practices are generally used. These include fewer years of row crops in sequence with oats and meadow, contour farming, and minimum tillage.

CAPABILITY UNIT IIw-1

This unit consists of deep, nearly level to gently sloping, poorly drained and somewhat poorly drained soils of the Calco, Colo, and Spillville series. These are mainly nearly level, poorly drained soils on bottom lands. The Spillville soils are somewhat poorly drained. The Colo-Spillville complex is gently sloping. The surface layer and the underlying material of these soils are silty clay loam or loam. Slopes range from 0 to 5 percent.

The Calco and Colo soils have moderately slow permeability, and the Spillville soils have moderate permeability. All the soils in this unit have high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is medium in the surface layer of the Colo and Spillville soils, and it ranges from very low to low in the surface layer of the Calco soil. The content of available phosphorus is medium in the underlying material of the Colo soils, low or medium in the underlying material of the Spillville soils, and very low to medium in the underlying material of the Calco soil. The content of available potassium ranges from very low to low in the surface layer of the Calco soil, and it is medium in the surface layer of the Colo and Spillville soils. The content of available potassium generally is low or medium in the underlying material of the Colo and Spillville soils, and it is very low or low in the underlying material of the Calco soil. Reaction is slightly acid or neutral in the surface layer of the Colo and Spillville soils, and it is moderately alkaline or mildly alkaline in the surface layer of the Calco soil.

These soils are used mainly for cultivated crops and pasture. They are well suited to corn, soybeans, small grain, and alfalfa and other hay and pasture plants. Row crops can be grown much of the time if erosion is controlled. Lime is needed in places on some of these soils. These soils are fairly easy to work, but if they are worked when wet they are likely to become hard and cloddy when dry. These soils generally dry late in spring, and planting is delayed in years of heavy rainfall. A seasonal high water table, flooding, or both tend to keep these soils wet. Although the Spillville soils are flooded occasionally, they do not stay wet as long as the Calco and Colo soils. The frequency of flooding varies from place to place, but many areas commonly must be replanted because of flooding.

In places diversion terraces are needed for protection against runoff from higher areas. Crops grow better and the soils are easier to manage where drainage is improved, but tile drainage is not feasible in some areas because suitable outlets are not available. Also, tile drains do not function where outlets are covered by flood water. Ditches, dikes,

and stream channel improvements can be used in some areas to help control flooding.

CAPABILITY UNIT IIw-2

This unit consists of deep, nearly level, poorly drained soils of the Afton, Canisteo, Marcus, Spicer, and Webster series. Slopes range from 0 to 2 percent. The surface layer is silty clay loam, and the subsoil is silty clay loam or clay loam.

These soils have moderately slow or moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is medium in the surface layer of the Afton and Marcus soils. It ranges from very low to low in the surface layer of the Canisteo and Spicer soils and very low to medium in the Webster soils. The content of available potassium generally is very low or low in the subsoil of all the soils in this unit. Reaction is slightly acid or neutral in the surface layer of the Afton, Marcus, and Webster soils, and it is moderately alkaline or mildly alkaline in the surface layer of the Canisteo and Spicer soils.

These soils are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. Row crops can be grown much of the time if erosion is controlled. Lime is needed in places on some of these soils. The soils are fairly easy to work, but if they are worked when wet they are likely to become hard and cloddy when they dry. These poorly drained soils tend to warm somewhat more slowly in spring than better drained soils, and they dry more slowly after rains. Planting is sometimes delayed in years of heavy rainfall. These soils have a seasonal high water table, and they have a moderate limitation because of wetness in cultivated areas.

Since wetness sometimes delays plowing in spring, these soils generally are plowed in fall. The fall plowing improves soil tilth by exposing the soil to freezing and thawing as well as to wetting and drying. Better seedbeds can be prepared as a result, but fall plowing subjects the soils to soil blowing. This hazard can be reduced by leaving a roughly plowed surface with alternating plowed and unplowed strips. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces soil blowing. An occasional year of meadow also improves tilth and helps to control weeds and insects. Grassed waterways are needed in places, especially on the Afton soils. They protect against erosion caused by runoff from higher areas. Tile drains function well in all areas of these soils except for a few places where suitable outlets are not available. Tile drainage is essential in cultivated areas.

CAPABILITY UNIT IIw-3

This unit consists of moderately deep or deep, nearly level, poorly drained and very poorly drained soils of the Biscay and Talcot series. The surface layer generally is clay loam, and the subsoil is clay loam or sandy clay loam. The moderately deep soils have sand and gravel at a depth of 24 to 32 inches, and the deep soils have sand and gravel at a depth of 32 to 40 inches. Slopes range from 0 to 2 percent.

The soils in this unit have moderate or moderately slow permeability above the sand and gravel and rapid permeability in the sand and gravel. The moderately deep soils have low or medium available water capacity, and the deep soils have medium or high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil. The fertility of the Biscay soil generally is higher than that of the Talcot soils. Reaction generally is neutral in the surface layer of the Biscay soil and mildly alkaline or moderately alkaline in the surface layer of the Talcot soils.

These soils are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. Row crops can be grown much of the time if drainage is adequate and soil blowing is controlled. Lime is not needed on these soils. In dry years the soils sometimes produce lower yields than the soils in capability units IIw-1 and IIw-2. These soils are fairly easy to work, but if they are worked when wet, they are likely to become hard and cloddy when they dry. These poorly drained soils tend to warm somewhat more slowly in spring than better drained soils, and they dry more slowly after rains. Planting is sometimes delayed in years of heavy rainfall. These soils have a seasonal high water table, and they have a moderate limitation because of wetness in cultivated areas.

Since wetness sometimes delays plowing in spring, these soils generally are plowed in fall. The fall plowing improves soil tilth by exposing the soil to freezing and thawing as well as to wetting and drying. Better seedbeds can be prepared as a result, but fall plowing also makes the soils more susceptible to soil blowing. This hazard can be reduced by leaving a roughly plowed surface with alternating plowed and unplowed strips. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces soil blowing. An occasional year of meadow also improves tilth and helps to control weeds and insects. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. Tile drains function well in these soils, but the drains may be difficult to install in the underlying sand and gravel. Tile drainage is essential on these soils in cultivated areas.

CAPABILITY UNIT IIw-4

Harps loam, 0 to 2 percent slopes, is the only soil in this capability unit. This highly calcareous, nearly level, poorly drained soil generally is on narrow rims of depressions on glacial till uplands. The surface layer is loam or light clay loam, and the subsoil is loam.

This soil has moderate permeability and moderate or high available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus and the content of available potassium in the surface layer and the subsoil are very low. Reaction is moderately alkaline in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to corn, soybeans, small grain, and alfalfa. Row crops can be grown much of the time if erosion is controlled. The soil has an excess of lime and is deficient in iron. Leaves of the soybeans that grow on this soil commonly show this iron deficiency by turning yellow when the plants are only a few inches high. The deficiency can be overcome by spraying the leaves repeatedly with a solution of ferrous sulfate. Also, some varieties of soybeans are better adapted than others to this soil. This soil is low in fertility, and fertilizer needs to be applied according to soil tests in areas of cultivated crops or areas of crops used for forage. It is friable and fairly easy to till. The soil has a seasonal high water table, and it has a moderate limitation because of wetness in cultivated areas.

An occasional year of meadow improves tilth and helps to control weeds and insects. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. Tile drains function well in this soil. Tile drainage is important for corn and soybean production.

CAPABILITY UNIT IIw-5

Waldorf silty clay loam, 0 to 2 percent slopes, is the only soil in this capability unit. This nearly level, poorly drained soil is on low-lying ground moraines in the glacial till uplands. The surface layer is heavy silty clay loam, and the subsoil is silty clay.

This soil has moderately slow permeability and moderate available water capacity. Content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium ranges from very low to medium in the surface layer to very low or low in the subsoil. Reaction generally is neutral in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to corn, soybeans, small grain, and alfalfa. Lime is seldom needed. This poorly drained, slowly permeable soil has a clayey subsoil and is fairly difficult to work. It warms more slowly in spring than the poorly drained soils in capability units IIw–2 and IIw–3, and it dries more slowly after rains. If this soil is worked when wet, it becomes hard and cloddy when dry. Planting is delayed in years of heavy rainfall. The soil has a seasonal high water table, and it has a moderate limitation for crops because of wetness.

Row crops can be grown on this soil much of the time. They grow much better and the soil is easier to manage if adequate drainage is provided. Since wetness sometimes delays plowing in spring, this soil generally is plowed in fall. The fall plowing improves soil tilth by exposing the soil to freezing and thawing during fall and winter months. An occasional year of meadow improves tilth and helps control weeds and insects. Grassed waterways are needed in places to carry excess water caused by runoff from higher areas. Tile drains are only fairly effective in this slowly permeable soil, and adequate drainage is difficult to establish. For the most effective drainage, tile lines need to be spaced more closely in this soil than in most soils.

CAPABILITY UNIT IIs-1

Wadena loam, moderately deep, 0 to 2 percent slopes, is the only soil in this capability unit. This nearly level, well-drained soil is on convex ridges in glacial outwash areas and on stream terraces. The surface layer and subsoil are loam. The soil has sand and gravel at a depth of 24 to 32 inches.

This soil has moderately rapid permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. It has moderate or low available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is very low or low in both the surface layer and the subsoil. Unless this soil is limed, reaction is slightly acid or medium acid in the surface layer.

This soil is used mainly for cultivated crops and pasture. It is well suited to corn, soybeans, small grain, and alfalfa. Lime generally is needed periodically. This soil warms early in spring and can be worked soon after rain ceases. It is friable and easy to work, but it is moderately susceptible to droughtiness.

Row crops can be grown on this soil much of the time. Such conservation practices as minimum tillage and contour farming, or both, are desirable in places and help to conserve moisture. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. An occasional year of meadow improves tilth and helps to control weeds and insects. Fall plowing makes the soil susceptible to soil blowing, but a roughly plowed surface with alternating plowed and unplowed strips reduces the hazard. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces the hazard of soil blowing and helps to conserve moisture.

CAPABILITY UNIT IIs-2

Cylinder loam, moderately deep, 0 to 2 percent slopes, is the only soil in this capability unit. This nearly level, somewhat poorly drained soil is in glacial till outwash areas and onstream terraces. The surface layer is loam, and the subsoil generally is loam. The soil has sand and gravel at a depth of 24 to 32 inches.

This soil has moderate permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. It has moderate or low available water capacity. The content of organic matter in the surface layer is moderate or high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and is very low or low in the subsoil. Reaction generally is slightly acid or neutral in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to corn, soybeans, small grain, and alfalfa. Lime is needed in places. This soil is friable and easy to work, but it is moderately susceptible to droughtiness.

Row crops can be grown on this soil much of the time. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. An occasional year of meadow improves tilth and helps to control weeds and insects. Fall plowing subjects the soils to soil blowing, but a roughly plowed surface with alternating plowed and unplowed strips reduces the hazard. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces the hazard of soil blowing and helps to conserve moisture.

CAPABILITY UNIT IIs-3

Collinwood silty clay loam, 0 to 2 percent slopes, is the only soil in this capability unit. This deep, nearly level, somewhat poorly drained soil is on undulating clayey-mantled ground moraines of the glacial till uplands. The surface layer is silty clay loam, and the subsoil is silty clay.

This soil has slow permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is low or medium in the surface layer and is very low or low in the subsoil. Reaction is slightly acid or neutral in the surface layer.

This soil is used mainly for cultivated crops. It is well suited to corn, soybeans, small grain, and alfalfa. Lime is needed in places for some crops. This soil has a clayey subsoil. It tends to warm somewhat more slowly in spring than the soils in capability units I–1 and I–2, and it dries more slowly after rains. It is fairly easy to work, but if it is worked when wet, it is likely to become hard and cloddy when dry.

Row crops can be grown on this soil much of the time. In wet years tile drains are beneficial in places. Since wetness sometimes delays field operations in spring, this soil generally is plowed in fall. Fall plowing improves soil tilth by exposing more of the soil to freezing and thawing action during fall and winter months. It also makes the soils more susceptible to soil blowing, but a roughly plowed surface with alternating plowed and unplowed strips reduces the hazard. Chisel plowing, which leaves all the crop residue on the surface, greatly reduces the hazard of soil blowing and helps to conserve moisture. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. An occasional year of meadow also improves tilth and helps to control weeds and insects.

CAPABILITY UNIT IIIe-1

This unit consists of deep, moderately sloping, somewhat poorly drained to somewhat excessively drained soils of the Clarion, Collinwood, Everly, Galva, Sac, Storden, and Terril series. The surface layer is loam, clay loam, or silty clay loam. The subsoil or underlying material of most of these soils is loam, clay loam, or silty clay loam, but the subsoil of the Collinwood soil is silty clay. Slopes range from 4 to 9 percent.

The Clarion, Galva, Storden, and Terril soils; most of the Everly soils; and the Sac soils that have a loam substratum have moderate permeability. The Sac soils that have a clay loam substratum and the Everly soils that are associated with them have moderately slow permeability. The Collinwood soil has slow permeability. All of the soils have high available water capacity. The content of organic matter in the surface layer generally is moderate, but it is high in the surface layer of the Terril soil, and it ranges from low to moderate in the surface layer of the moderately eroded soils. The content of available phosphorus generally is very low or low in the surface layer of the Clarion, Collinwood, Everly, Galva, Sac, and Storden soils, and it generally is medium in the surface layer of the Everly, Galva, and Sac soils. It generally is low or medium in the surface layer of the Clarion, Collinwood, Storden, and Terril soils. The content of available potassium is very low or low in the subsoil of all of these soils. Reaction is slightly acid or neutral in the surface layer of the Clarion, Collinwood, and Terril soils. It is slightly acid or medium acid in the surface layer of the Everly, Galva, and Sac soils unless these soils are limed, and it is mildly alkaline or moderately alkaline in the surface layer of the Storden soil.

These soils are used mainly for cultivated crops and pasture. They are only moderately well suited to row crops, but row crops can be grown if erosion is controlled. Lime is needed on many of these soils. All except the Collinwood soil are friable and easy to work. The Collinwood soil is somewhat more difficult to work. All of these soils are highly susceptible to erosion.

Such conservation practices as terracing, contour farming, and minimum tillage all help to control erosion. Growing fewer row crops and more small grain and meadow is also needed to control erosion where terraces are not used. In most places it is easy to build terraces on the Galva and Sac soils because they generally have long, uniform slopes. The Everly and Terril soils generally have short, uniform slopes, but the Clarion, Collinwood, and Storden soils generally have short, irregular slopes. It is very difficult to build terraces on soils that have short, irregular slopes.

Where cuts in building terraces expose the subsoil or underlying material in these soils, special efforts are needed to restore fertility and tilth to the exposed areas. In the Clarion, Galva, and Terril soils and in much of the Everly and Sac soils cuts generally do not expose calcareous material. Fertility and tilth generally can be restored to the subsoil cuts in a few years by spreading a layer of topsoil and large amounts of crop residue and manure over the exposed area. Depth to underlying calcareous, loamy material in the Clarion, Everly, and Sac soils generally ranges from 24 to 40 inches, and in the Storden soil it is less than 10 inches. Where cuts in building terraces expose this underlying calcareous material, tilth generally can be restored in a few years.

It takes many years, however, to restore or even partly restore fertility to the exposed calcareous areas in the Storden, Clarion, Everly, and Sac soils. Calcareous soils that have a low content of organic matter, such as the Storden soil, have very low fertility.

The combination of excess calcium and moderately alkaline reaction in the calcareous soils lowers the solubility and availability of phosphorus and promotes leaching of the soluble potassium. Additions of topsoil, crop residue, and manure are needed in the restoration process. Where cuts expose the firm clay loam subsoil in the Sac soils that have a clay loam substratum and the associated Everly soil, additional years are needed for the restoration of both fertility and tilth to these exposed areas. Also, a thicker layer of topsoil and large amounts of crop residue and manure are needed in the restoration process.

In the Collinwood soil the cuts expose a clayey subsoil that has very poor tilth. It is very unlikely that tilth can be restored to these cuts, and terracing this slowly permeable soil is likely to create a moisture problem, especially in wet years. It is therefore desirable in many places to use conservation practices other than terracing for erosion control on this Collinwood soil.

Diversion terraces are needed in places to protect the Terril soil against runoff from steeper slopes. Grassed waterways are needed in places on all of the soils of this unit for protection against erosion caused by runoff from higher areas. When row crops are grown on these moderately sloping soils, adequate erosion-control practices are needed.

CAPABILITY UNIT IIIe-2

This unit consists of moderately eroded, strongly sloping, well-drained and somewhat excessively drained loams of the Clarion and Storden series. Slopes range from 9 to 14 percent.

These soils have moderate permeability and high available water capacity. The content of organic matter in the surface layer ranges from low to moderate. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil or the underlying material. The content of available potassium is low or medium in the surface layer of the Clarion soil and generally is low in the surface layer of the Storden soil. The content of available potassium is very low or low in the subsoil of the Clarion soil and very low in the underlying material of the Storden soil. Reaction is slightly acid or neutral in the surface layer of the Clarion soil and mildly alkaline or moderately alkaline in the surface layer of the Storden soil.

The soils of this unit are used mainly for such crops as corn, soybeans, oats, and alfalfa. They are also used for pasture. The soils are only moderately well suited to row crops, but row crops can be grown if erosion is controlled. Lime is needed on the Clarion soil in places. These soils are

friable and easy to work, but they are highly susceptible to erosion.

Such conservation practices as terracing, contour farming, and minimum tillage all help to control erosion. In places it is very difficult to build terraces on these soils because of the short, irregular slopes. Where cuts in building terraces expose the subsoil in the Clarion soil and the underlying material in the Storden soil, fertility and tilth can generally be restored in a few years by spreading a layer of topsoil and large amounts of crop residue and manure over the cuts. Extra effort is needed where calcareous material is exposed in the cuts. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. When these soils are cultivated, adequate erosion-control practices are needed.

CAPABILITY UNIT IIIe-3

Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded, is the only soil in this capability unit. This moderately sloping, well-drained soil is on convex ridges in glacial outwash areas and on stream terraces. The surface layer and subsoil are loam. The soil is underlain by sand and gravel at a depth of 24 to 32 inches.

This soil has moderately rapid permeability above the sand and gravel and rapid or very rapid permeability in the sand and gravel. It has moderate or low available water capacity. The content of organic matter in the surface layer is moderately low or moderate. The content of available phosphorus generally is very low or low in the surface layer and very low in the subsoil. The content of available potassium generally is very low or low in the surface layer and the subsoil. Unless this soil is limed, reaction is medium acid or slightly acid in the surface layer.

This soil is used mainly for such crops as corn, soybeans, small grain, and alfalfa. It is also used for pasture. It is only moderately well suited to row crops, but row crops can be grown if erosion is controlled. Lime generally is needed periodically. This soil is friable and easy to work, but it is moderately susceptible to droughtiness and highly susceptible to erosion.

Such conservation practices as terracing, contour farming, and minimum tillage all help to control erosion and conserve moisture. An occasional year of meadow improves tilth and helps to control weeds and insects. In building terraces, deep cuts should be avoided because the sandy or gravelly underlying material has very low available water capacity and very low fertility.

CAPABILITY UNIT IIIe-4

This unit consists of gently sloping, somewhat excessively drained soils of the Dickinson and Estherville series. The surface layer and subsoil range from loam to fine sandy loam. The Dickinson soil is underlain by loamy sand and sand, generally at a depth of 24 to 40 inches. The Estherville soils are underlain by sand and gravel at a depth of 15 to 24 inches. Slopes range from 2 to 5 percent.

These soils have moderately rapid permeability and very low or low available water capacity. The underlying sand and gravel has rapid or very rapid permeability. The content of organic matter in the surface layer is moderately low or moderate. The content of available potassium generally is low or medium in the surface layer of the Dickinson soil and very low or low in the surface layer of the Estherville soils. The content of available potassium is very low in the subsoil of these soils. Unless these soils are limed, reaction is medium acid or slightly acid in the surface layer.

These soils are used mainly for cultivated crops and pasture. They are only moderately well suited to row crops, but row crops can be grown much of the time if erosion is controlled. Many small areas of these soils are as intensively cultivated as the more productive soils surrounding them. Lime generally is needed periodically. Additions of fertilizer are beneficial on cultivated crops and forage, but large applications of fertilizer are not economical on these droughty soils. These soils warm early in spring, and they can be worked soon after a rain. These soils are friable and easy to work, but they are highly susceptible to droughtiness, soil blowing, and water erosion.

Such conservation practices as terracing, contour farming, and minimum tillage all help to control erosion and conserve moisture. Minimum tillage practices that leave crop residue on the surface greatly reduce the hazard of soil blowing. In building terraces, deep cuts should be avoided because exposing the underlying sand or sand and gravel would reduce the already low available water capacity and the productivity of these soils. In order to maintain the highest possible available water capacity, it is more desirable in places to use conservation practices other than terracing for erosion control. A cropping sequence that includes row crops, small grain, and meadow is also effective. Excess soil loss caused by soil blowing or water erosion can lower the available water capacity and productivity of these soils, especially the Estherville soils. When these highly droughty and erodible soils are cultivated, adequate erosion-control practices are needed to maintain their already low available water capacity and productivity.

CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained, depressional soils of the Okoboji and Rolfe series. Slopes range from 0 to 1 percent. These soils are in shallow potholes or in landlocked depressions. The surface layer is silty clay loam in the Okoboji soil, and it is silt loam in the Rolfe soil. The subsoil is silty clay or silty clay loam in both of these soils.

These soils have slow permeability and high available water capacity. The content of available phosphorus is medium or high in the surface layer of the Okoboji soil and very low or low in the surface layer of the Rolfe soil. The content of available phosphorus is very low in the subsoil of both of these soils. The content of available potassium is medium or high in the surface layer of the Okoboji soil, and it ranges from very low to medium in the surface layer of the Rolfe soil. The content of available potassium is very low or low in the subsoil of both of these soils. Reaction generally is slightly acid or neutral in the surface layer of the Okoboji soil. It is medium acid or slightly acid in the surface layer of the Rolfe soil, unless this soil is limed.

These soils are used mainly for cultivated crops. They are only moderately well suited to corn, soybeans, small grain, and alfalfa, but row crops can be grown if erosion is controlled. Lime generally is needed on the Rolfe soil, but it seldom is needed on the Okoboji soil. These soils are fairly easy to work when dry, but if they are worked when wet they are likely to become hard and cloddy when dry. These very poorly drained, depressional soils collect water and are subject to ponding after rains and in spring when snow melts. They have a seasonal high water table. In cultivated areas these soils have a severe limitation because of wetness. Without improved drainage, they generally are too wet for cultivation.

In addition to tile drains, shallow ditches and open inlets leading to the tile lines are often needed for quick removal

of surface water. Tile drains are only fairly effective in these slowly permeable soils. In places tile outlets must be placed very deep, and in a few places suitable tile outlets are not available. An occasional year of meadow improves tilth and helps to control weeds and insects. Maintainance of a good drainage system on these soils is essential for intensive production of corn and soybeans.

CAPABILITY UNIT IIIw-2

This unit consists of very poorly drained, depressional soils of the Blue Earth, Lanyon, and Wacousta series. Slopes range from 0 to 1 percent. These soils are in shallow glacial lake basins. The surface layer is mucky silt loam in the Blue Earth and Wacousta soils, and it is silty clay loam in the Lanyon soil. The subsoil or underlying material is silt loam or silty clay loam in the Blue Earth and Wacousta soils, and it is silty clay in the Lanyon soil.

The Blue Earth and Wacousta soils have moderate or moderately slow permeability, and the Lanyon soil has slow permeability. The Blue Earth soil has high or very high available water capacity, and the Lanyon and Wacousta soils have high available water capacity. The content of organic matter is very high in the surface layer of the Blue Earth and Wacousta soils and high in the surface layer of the Lanyon soil. The content of available phosphorus generally is very low or low in the surface layer and is very low in the subsoil or underlying material of all of these soils. The content of available potassium ranges from very low to medium in the surface layer and is very low or low in the subsoil or underlying material of all of the soils in this unit. Reaction is moderately alkaline or mildly alkaline in the surface layer of the Blue Earth and Lanyon soils and neutral or slightly acid in the surface layer of the Wacousta soil.

These soils are used mainly for cultivated crops. They are only moderately well suited to corn, soybeans, small grain, and alfalfa, but row crops can be grown if drainage is adequate and soil plowing is controlled. The Blue Earth and Lanyon soils have excess lime, and the Wacousta soil seldom needs lime. These soils are fairly easy to work when dry, but if they are worked when wet, they are likely to become hard and cloddy when dry. The Lanyon soil, however, is somewhat more difficult to work than the others. The soils of this unit are subject to ponding after rains and in spring when snow melts. They have a seasonal high water table. These soils have a severe limitation because of wetness in cultivated areas. Without improved drainage, they generally are too wet for cultivation.

In addition to tile drains, drainage ditches are often needed for quick removal of surface water. Tile drains are only fairly effective in the slowly permeable Lanyon soil, but they function well in the Blue Earth and Wacousta soils where suitable tile outlets are available. An occasional year of meadow improves tilth and helps to control weeds and insects. A good drainage system on these soils is essential in cultivated areas.

CAPABILITY UNIT IVe-1

Storden loam, 14 to 18 percent slopes, is the only soil in this capability unit. This moderately steep, calcareous soil is on convex side slopes of glacial till plains. The surface layer and the underlying material are loam.

This soil has moderate permeability and high available water capacity. The content of organic matter in the surface layer is low. The content of available phosphorus is very low or low in the surface layer and very low in the underlying material. The content of available potassium generally is low in the surface layer and is very low in the underlying material. Reaction is moderately alkaline or mildly alkaline in the surface layer.

This soil is used mainly for pasture and cultivated crops. It is only moderately well suited to row crops, but they can be grown if erosion is controlled. This soil has an excess of lime. It generally is in good tilth and is easy to work, except in areas where the soil is severely eroded. In dry weather this soil is more droughtly than less sloping Storden soils. This soil is highly susceptible to erosion.

Such conservation practices as terracing, contour farming, grassed waterways, and minimum tillage all help to control erosion, but even with all of these, the rate of soil loss on this moderately steep soil is too great to permit intensive cultivation. Also it is very difficult to build terraces on this soil because of the moderately steep, short, irregular slopes. Where this soil is cultivated, corn generally is grown on the contour for a year, and the soil is then reseeded to meadow or pasture grasses. Alfalfa or an alfalfa-bromegrass mixture is then commonly planted and allowed to remain on the soil until the stand becomes thin. Another row crop is then planted on the contour before the meadow or pasture is reestablished. Whenever this highly erodible soil is cultivated, adequate erosion-control practices are needed.

CAPABILITY UNIT IVs-1

Salida gravelly sandy loam, 5 to 9 percent slopes, is the only soil in this capability unit. This moderately sloping, excessively drained soil has a surface layer and a subsoil of sandy loam or gravelly sandy loam. The soil is underlain by sand and gravel at a depth of about 1 to 1 1/2 feet.

This soil has moderately rapid or rapid permeability and very low available water capacity. The content of organic matter in the surface layer ranges from very low to moderately low. The content of available phosphorus and the content of available potassium generally are very low or low in the surface layer and very low in the subsoil. Reaction is moderately alkaline or mildly alkaline in the surface layer.

This soil is used mainly for pasture and cultivated crops. It is poorly suited to row crops, but row crops can be grown if erosion is controlled. Many small areas of this soil are cultivated in the same manner as the more productive soils surrounding them. Additions of fertilizer are beneficial on cultivated crops and forage, but large applications of it are not economically feasible. This soil warms early in spring, and it can be worked soon after rains. It is very friable and easy to work, but it generally has many rocks on the surface. This soil is susceptible to both water erosion and soil blowing.

Such conservation practices as contour farming and minimum tillage help to control erosion and conserve moisture. Minimum tillage practices that leave crop residue on the surface also greatly reduce the hazard of soil blowing. Terraces are not desirable on this soil, because cuts in building terraces commonly expose the underlying sand and gravel and greatly reduce the already very low available water capacity. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. A cropping sequence that includes row crops, small grain, and meadow also helps to reduce soil losses caused by erosion. When this highly droughty and erodible soil is cultivated, adequate erosion-control practices are needed to maintain its already very low available water capacity and productivity.

CAPABILITY UNIT Vw-1

This unit consists of nearly level and gently sloping, poorly drained and somewhat poorly drained, channeled soils of the Colo, Millington, and Spillville series. These soils are on bottom lands that are dissected by many stream channels and are frequently flooded. Slopes range from 0 to 5 percent. The surface layer is silty clay loam in the Colo soils and loam in the Millington and Spillville soils. The underlying material of these soils generally is silty clay loam or loam.

These soils have moderately slow or moderate permeability and high available water capacity. The content of organic matter in the surface layer is high. The content of available phosphorus generally is medium in the surface layer of the Colo and Spillville soils, and it ranges from very low to medium in the surface layer of the Millington soil. The content of available phosphorus is low or medium in the surface layer of the Millington soil. The content of available potassium generally is low or medium in the underlying material of the Colo and Spillville soils and generally is very low or low in the underlying material of the Millington soil. Reaction is slightly acid or neutral in the surface layer of the Colo and Spillville soils and generally is moderately alkaline or mildly alkaline in the surface layer of the Millington soil.

Generally, trees and brush grow on these soils, or the areas are open and are used for pasture. The soils are so cut by stream channels or are so frequently flooded that they seldom are cultivated. In places serveral inches of sediment have recently been deposited on the surface. The wooded areas have poor stands and generally are managed in the same manner as the surrounding unimproved pasture, which generally is not fertilized. A few areas are used for wildlife habitat and for recreation. These soils are poorly suited to row crops, but many areas are suitable for improved pasture. Lime is needed in places on the Colo and Spillville soils, but the Millington soil generally has an excess of lime. Applications of fertilizer are beneficial on improved pasture. These soils generally are too wet for cultivation.

Seeding and fertilizing of these channeled soils is worthwhile if flooding is not too frequent. Canarygrass, birdsfoot trefoil, or a mixture of birdsfoot trefoil and bluegrass are possible seeding mixtures. It is practical in places to fence livestock out of wooded areas and manage these areas as woodland. Where areas are to be developed for wildlife shelters, a mixed stand of conifers, shrubs, hedges, and grasses that tolerate wetness and flooding is required. Generally, the most worthwhile use of these channeled soils is for pasture that is improved and well managed.

CAPABILITY UNIT Vw-2

Fill land is the only mapping unit in this capability unit. This nearly level, very poorly drained to poorly drained land type consists of areas around Storm Lake that are filled with medium-textured and moderately fine textured material. Commonly, it consists of strata of silt loam, silty clay loam, and very fine sandy loam that have thin lenses and pockets of sand and clay.

Fill land is used mainly for public parks. It is poorly suited to row crops and generally is too wet for cultivation.

CAPABILITY UNIT VIe-1

This unit consists of steep, well-drained and somewhat excessively drained soils of the Lester and Storden series. The surface layer is loam, and the subsoil or underlying material is clay loam or loam. Slopes range from 18 to 25 percent.

These soils have moderate permeability and high available water capacity, but the amount of mositure absorbed is low because of rapid runoff on the steep slopes. The content of organic matter in the surface layer is low or very low. The content of available phosphorus is very low or low in the surface layer of the soils in this unit. The content of available phosphorus is low or medium in the subsoil of the Lester soil and very low in the subsoil of the Storden soil. The content of available potassium is very low or low in the subsoil of the Lester soil and very low in the underlying material of the Storden soil. Reaction is medium acid or slightly acid in the surface layer of the Lester soil, unless it has been limed, and it is moderately alkaline or mildly alkaline in the surface layer of the Storden soil.

These soils are used for pasture, woodland pasture, or woodland. They are poorly suited to cultivated crops, but some areas are suited to improved permanent pasture. Some of the wooded areas, especially areas of the Lester soils, are suited to woodland. Other areas are better suited to permanent native pasture and woodland pasture. The growth of pasture plants is poor in the shaded woodland pasture, and the growth of native prairie grasses on the unimproved pasture generally is moderate or poor. The Lester soil generally needs lime where improved pasture is established. The Storden soil has a natural excess of lime. Additions of fertilizer are beneficial to both the unimproved native prairie-grass pasture and the improved permanent pasture. These soils are very highly susceptible to erosion.

Improved management of these steep soils is worthwhile in some areas, but the operation of farm machinery is difficult. Permanent pasture can be improved in places by renovating and reseeding. Preparation of the seedbeds is difficult, and farm machinery needs to be operated carefully. The seedbeds can be reseeded with mixtures of alfalfa and bromegrass or birdsfoot trefoil and bluegrass. Where it is not feasible to renovate the native pasture, phosphate fertilizers and weed and brush control improve the stand of such native prairie grasses as big and little bluestem and side-oats grama. Controlled grazing of all permanent pasture is also needed. In places wooded areas will provide more income if they are managed as woodland rather than as woodland pasture. The areas most suitable for woodland management require protection from the grazing livestock and the cutting of undersirable trees. The more desirable trees, as a result, will have more room for better growth without being damaged by livestock. For information on suitable trees for these soils, refer to the section "Use of the Soils for Environmental Plantings." The names of the specific soils in this unit and their environmental group numbers are given in the "Guide to Mapping Units" at the back of this publication.

CAPABILITY UNIT VIs-1

Salida gravelly sandy loam, 9 to 14 percent slopes, is the only soil in this capability unit. This shallow, strongly sloping, excessively drained soil is in small kames or knobs on glacial till plains and on convex side slopes of glacial outwash stream terraces. The surface layer and the subsoil are gravelly sandy loam. This soil is underlain by sand and gravel at a depth of only 7 to 18 inches.

This soil has very rapid permeability and very low available water capacity. The content of organic matter is low or very low in the surface layer. The content of available

phosphorus generally is very low or low in the surface layer and very low in the subsoil. Reaction generally is moderately alkaline in the surface layer.

This soil is used mainly for pasture and cultivated crops. It is poorly suited to row crops, but row crops can be grown if erosion is controlled. The areas of this soil generally are small. Most of them are used in the same manner as the surrounding soils. This soil generally has an excess content of lime. Applications of fertilizer are beneficial on forage and cultivated crops, but large applications of fertilizer are not economically feasible on this droughty soil. This soil is very friable and easy to work, but it generally has many rocks on the surface. It is highly susceptible to both water erosion and soil blowing.

Such conservation practices as contour farming and minimum tillage help to control erosion and conserve moisture. Minimum tillage practices that leave crop residue on the surface also greatly reduce the hazard of soil blowing. Terraces are not desirable on this shallow soil, because cuts in building terraces commonly expose the underlying sand and gravel and greatly reduce the already very low available water capacity. Grassed waterways are needed in places for protection against erosion caused by runoff from higher areas. A cropping sequence that includes row crops, small grain, and meadow can also be used to reduce soil losses caused by erosion. Even with all of these practices, the rate of soil loss on this strongly sloping, droughty, shallow soil is still too great for intensive cultivation. Any excess soil loss caused by either soil blowing or water erosion is likely to lower the available water capacity and thereby lower the already low productivity of this shallow, droughty soil. Thus, adequate erosion-control practices are essential in cultivated areas.

CAPABILITY UNIT VIIe-1

This unit consists of very steep, well-drained and somewhat excessively drained soils of the Lester and Storden series. Slopes range from 25 to 40 percent. The surface layer is loam, and the underlying material is clay loam or loam.

These soils have moderate permeability and high available water capacity, but the amount of moisture actually absorbed is low because of rapid runoff. The content of organic matter in the surface layer is low or very low. The content of available phosphorus is low or very low in the surface layer of these soils. The content of available phosporus is low or medium in the subsoil of the Lester soil and very low in the underlying material of the Storden soil. The content of available potassium is low or medium in the surface layer of the Lester soil and is low in the surface layer of the Storden soil. The content of available potassium is very low or low in the subsoil of the Lester soil and very low in the underlying material of the Storden soil. Reaction generally is medium acid in the surface layer of the Lester soil and moderately alkaline in the surface layer of the Storden soil.

These soils are used for pasture, woodland pasture, and woodland. They are not suited to cultivated crops. They are better suited to permanent pasture, woodland, or woodland pasture. The growth of pasture plants is poor in the shaded woodland pasture and the growth of the native prairie grasses is moderate or poor in the permanent pasture. Where the Lester soil is in permanent pasture, lime generally is needed. The Storden soil has an excess of lime. Additions of fertilizer, especially phosphates, are beneficial on the native prairie-grass pasture, but it is very difficult to apply fertilizer by farm machinery. The soils of this unit are very highly susceptible to erosion.

Controlled grazing and control of weeds and brush are needed on the permanent pasture to maintain a good stand of native prairie grasses such as big and little bluestem and side-oats grama. The areas most suitable for woodland management require protection from the grazing of livestock and the cutting of undesirable trees. The more desirable trees, as a result, will have more room for better growth without being damaged by livestock. For information on suitable trees for these soils, refer to the section "Use of the Soils for Environmental Plantings." The names of the specific soils in the unit and their environmental group numbers are given in the "Guide to Mapping Units" at the back of this publication.

CAPABILITY UNIT VIIw-1

Marsh is the only mapping unit in this capability unit. This land type consists of areas that are under water most of the time. Marsh is better suited to wildlife habitat than to other uses. It is not suited to farming. Willows, cattails, rushes, sedges, and other plants that tolerate wetness grow well in Marsh. Waterfowl, muskrats, and upland game find cover, food, and nesting places in and around these marshy areas.

CAPABILITY UNIT VIIs-1

Gravel pits is the only mapping unit in this capability unit. These excavated areas are on stream terraces and in glacial outwash areas that have or have had substantial deposits of sand and gravel.

Many gravel pits are active and supply the sand and gravel needs of the county. Others have been abandoned but left open, and many are used as dumping places for old farm machinery. These excavated areas are poorly suited to row crops. In the low-lying areas the abandoned gravel pits are used as stock ponds for fishing, and a few are used for public parks that have areas for fishing, picnicking, and swimming.

Predicted yields

Table 2 gives the predicted average yields per acre of the principal crops in Buena Vista County under a high level of management. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of adapted varieties; erosion is controlled; the content of organic-matter and tilth are maintained; the level of fertility for each crop is maintained (as indicated by soil tests and field trials); the water level in wet soils is controlled; excellent weed and pest control are provided; and operations are timely.

Many available sources of yield information were used to make these estimates, including data from the federal census, the Iowa farm census, data from experimental farms and cooperative experiments with farmers, and from on-farm experience by soil scientists, extension workers, and others.

The yield predictions are meant to serve as guides. They are only approximate values and should be so considered. Of more value than actual yield figures to many users are the comparative yields among soils. These relationships are likely to remain consistent over a period of years, but actual yields have been increasing in recent years. If they continue to increase as expected, predicted yields in this table will be outdated in a few years.

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*

Soil	Corn	Soybeans	Oats	Alfalfa-grass hay	Pasture
	Bu	*Bu*	*Bu*	*Tons*	*A.U.D.*[1]
Afton silty clay loam, 0 to 2 percent slopes	98	37	83	4.0	200
Biscay clay loam, deep, 0 to 2 percent slopes	93	35	74	3.7	185
Blue Earth mucky silt loam, 0 to 1 percent slopes	87	33	70	3.5	175
Calco silty clay loam, 0 to 2 percent slopes	92	35	74	3.7	185
Canisteo silty clay loam, 0 to 2 percent slopes	98	37	78	3.9	195
Clarion loam, 2 to 5 percent slopes	100	38	80	4.2	210
Clarion loam, 5 to 9 percent slopes, moderately eroded	92	35	74	4.0	200
Clarion loam, 9 to 14 percent slopes, moderately eroded	83	31	67	3.7	185
Clarion silty clay loam, 2 to 5 percent slopes	97	37	78	4.1	205
Collinwood silty clay loam, 0 to 2 percent slopes	93	35	74	3.8	190
Collinwood silty clay loam, 2 to 5 percent slopes	85	32	68	3.7	185
Collinwood silty clay loam, 5 to 9 percent slopes	79	30	63	3.4	170
Colo silty clay loam, 0 to 2 percent slopes	97	37	78	3.9	195
Colo-Spillville complex, 2 to 5 percent slopes	86	33	69	3.5	175
Colo-Spillville complex, channeled, 0 to 2 percent slopes	[2]---	---	---	3.0	150
Cylinder loam, deep, 0 to 2 percent slopes	96	36	77	4.0	200
Cylinder loam, moderately deep, 0 to 2 percent slopes	82	31	66	3.4	170
Dickinson fine sandy loam, 2 to 5 percent slopes	58	22	46	2.0	100
Ely silty clay loam, 2 to 5 percent slopes	104	39	88	4.8	240
Estherville sandy loam, 2 to 5 percent slopes	33	13	26	1.6	80
Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	19	7	15	1.5	75
Everly clay loam, 2 to 5 percent slopes	94	36	80	3.7	185
Everly clay loam, 5 to 9 percent slopes	89	34	76	3.5	175
Everly clay loam, 5 to 9 percent slopes, moderately eroded	86	33	73	3.4	170
Fill land	---	---	---	---	---
Galva silty clay loam, 0 to 2 percent slopes	102	39	87	4.1	205
Galva silty clay loam, 2 to 5 percent slopes	100	38	85	4.0	200
Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	92	35	78	3.7	185
Galva silty clay loam, benches, 1 to 3 percent slopes	102	39	87	4.1	205
Gravel pits	---	---	---	---	---
Harps loam, 0 to 2 percent slopes	88	33	70	3.7	185
Lanyon silty clay loam, 0 to 1 percent slopes	83	32	66	3.3	165
Lester loam, 18 to 25 percent slopes	---	---	---	---	[3] 50
Lester loam, 25 to 40 percent slopes	---	---	---	---	[3] 30
Marcus silty clay loam, 0 to 2 percent slopes	104	40	88	4.1	205
Marsh	---	---	---	---	---
Millington loam, channeled, 0 to 2 percent slopes	---	---	---	3.0	150
Nicollet loam, 1 to 3 percent slopes	110	42	88	4.7	235
Nicollet silty clay loam, 1 to 3 percent slopes	105	39	84	4.6	230
Okoboji silty clay loam, 0 to 1 percent slopes	78	30	62	3.2	160
Primghar silty clay loam, 0 to 2 percent slopes	109	41	93	4.6	230
Primghar silty clay loam, 2 to 4 percent slopes	107	40	91	4.5	225
Rolfe silt loam, 0 to 1 percent slopes	65	25	52	3.0	150
Sac silty clay loam, loam substratum, 2 to 5 percent slopes	97	37	82	3.8	190
Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	89	34	76	3.5	175
Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	94	36	80	3.7	185
Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded	86	33	73	3.4	170
Salida gravelly sandy loam, 5 to 9 percent slopes	12	5	10	1.4	70
Salida gravelly sandy loam, 9 to 14 percent slopes	---	---	---	1.3	65
Spicer silty clay loam, 0 to 2 percent slopes	99	38	84	3.9	195
Spillville loam, 0 to 2 percent slopes	102	39	82	4.7	235
Spillville loam, 2 to 5 percent slopes	100	38	80	4.6	230
Storden loam, 5 to 9 percent slopes	82	32	65	3.5	175
Storden loam, 9 to 14 percent slopes	73	28	59	3.2	160
Storden loam, 14 to 18 percent slopes	59	23	47	2.7	135
Storden loam, 18 to 25 percent slopes	---	---	---	2.0	100
Storden loam, 25 to 40 percent slopes	---	---	---	---	[3] 35
Talcot clay loam, deep, 0 to 2 percent slopes	88	33	70	3.5	175
Talcot clay loam, moderately deep, 0 to 2 percent slopes	79	30	63	3.2	160
Terril loam, 4 to 9 percent slopes	100	38	80	4.2	210
Wacousta mucky silt loam, 0 to 1 percent slopes	93	35	74	3.7	185
Wadena loam, deep, 1 to 5 percent slopes	84	32	67	3.3	165
Wadena loam, moderately deep, 0 to 2 percent slopes	67	25	54	2.7	135
Wadena loam, moderately deep, 2 to 5 percent slopes	65	25	52	2.6	130
Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	58	22	46	2.4	120
Waldorf silty clay loam, 0 to 2 percent slopes	85	32	68	3.5	175
Webster silty clay loam, 0 to 2 percent slopes	102	39	82	4.1	205

[1] A.U.D. = animal-unit-days. The amount of forage or feed (alfalfa-grass pasture in this case) required to maintain one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 1 day. Based on the assumption that one mature animal consumes 40 pounds of dry matter per pasture day.

[2] Dashes indicate that the soil is not suited to the crop or that the crop generally is not grown on the soil.

[3] Bluegrass.

Use of the Soils for Wildlife Habitat and Recreation

Buena Vista County supports many kinds of wildlife that contribute to its income and recreation facilities. The kinds and amount of wildlife greatly depend on the kinds of soils, although this relationship between soils and wildlife is not always easily distinguished. The soils affect wildlife through their influence on the vegetation that supplies food and cover for the wildlife.

The amount and kinds of wildlife are influenced by topography, fertility, and other characteristics of the soils. Topography affects wildlife mainly through its effect on land use. Extremely rough, irregular areas, for example, may be hazardous to livestock and may be unsuited to crops. If these areas are left undisturbed, the plants are often valuable as food or cover for wildlife. Suitable vegetation can be provided where it is lacking, and the areas can be developed for desirable kinds of wildlife. Fertile soils are capable of producing more food and cover, and therefore more wildlife, than infertile soils.

The wetness of soils and their water-holding capacity are important in the selection of sites for fish ponds and in the maintenance of aquatic or semiaquatic habitat for waterfowl and some kinds of furbearing animals.

Under natural conditions, the patterns or combinations of vegetation in an area depend on the distribution of the various kinds of soils. An area is inhabited by the kinds of wildlife whose habitat requirements are met by the vegetation in the area. If the natural conditions in the area are altered by drainage or by the other practices used in managing farmland or woodland, the kinds and patterns of vegetation change. With this change in vegetation, there may also be a change in the kinds and amount of wildlife.

The wildlife resources of Buena Vista County provide many opportunities for recreation. Many kinds of wildlife, however, are also beneficial because they eat harmful insects and rodents. Many kinds of birds eat insects; hawks, owls, and other avian predators help keep the number of rodents tolerable; and shrews, skunks, foxes, and snakes also feed on rodents.

Pheasant, Hungarian partridges, cottontail rabbits, jackrabbits, squirrels, and deer are the same that provide much of the hunting in the county. The distribution of pheasants, partridges, and rabbits is fairly uniform throughout the county. Many of the soils throughout the county are used intensively for row crops, and the wildlife cover needed for shelter and nesting is somewhat limited. This is especially true in areas of the Clarion, Nicollet, Canisteo, and Webster soils in soil association 1 and areas of the Sac, Primghar, and Galva soils in soil associations 2 and 3. Squirrels and deer are most numerous in areas of the Storden and Lester soils in soil association 7 and in areas of the Colo, Spillville, and Millington soils in soil association 4. In these associations the kinds of trees, food supply, and cover favor these animals. The number of opossums, raccoons, weasels, badgers, foxes, and skunks varies throughout the county.

The area of marsh around Little Storm Lake and the poorly drained to very poorly drained soils in soil association 1 are the most favorable for muskrats and minks. These animals also inhabit areas along the streams and drainage ditches throughout the county. Clarion, Nicollet, Canisteo, and Webster soils are the major soils in soil association 1. Many of the drainage ditches in the association serve as outlets for the tile drainage systems and provide water for most of the year, if not all of it.

Storm Lake and small, shallow lakes in the county are used by migrating waterfowl for feeding and nesting. Mallard, teal, and other ducks nest and raise their young in these areas. These are good areas for hunting ducks and geese in the fall.

Fishing is a popular sport in Buena Vista County. Storm Lake, Little Storm Lake, Picheral Lake, and the Little Sioux River abound with such popular warm-water sport fish as walleyed pike, bass, catfish, panfish, and bullheads. Also, a few farm ponds have been stocked with fish and provide excellent fishing where they are properly managed. The Storden soils provide good construction material for ponds, and suitable sites frequently are available. The Clarion and Everly soils and many other soils provide suitable material but seldom have good sites for ponds. More good sites for ponds are in soil associations 1, 2, 3, and 7 than in the other soil associations.

The development of outdoor recreation facilities, such as camping and picnic grounds, play areas, and hiking, nature study, and bridle trails are influenced by the soils, topography, vegetation, and land use. Important properties in evaluating soils for these facilities are trafficability, slope, and hazard of flooding. In Buena Vista County the areas around the lakes, the areas adjacent to the Little Sioux River, and the wooded areas on rough topography along the Little Sioux River across the northwestern part of the county all have good potential for futher development of outdoor recreation facilities.

All of the soils in the county are suitable for some form of outdoor recreation or some kind of wildlife, but many are more suitable for producing cultivated crops. Of the soils in capability classes I, II, III, and IV, crops generally are more valuable than recreation facilities or wildlife, but wildlife may be plentiful on these soils. Areas that are used for outdoor recreation facilities or wildlife generally are on soils in classes V, VI, and VII. These soils are better suited to recreation facilities, wildlife habitat, woodland, or pasture than they are to other uses. Information and technical assistance in developing wildlife habitat can be obtained from the Iowa State Conservation Commission and from the Soil Conservation Service.

Use of the Soils for Environmental Plantings

In this section the soils of Buena Vista County are placed in four groups according to their suitability for growing trees and shrubs, some of the important soil characteristics for each group are presented, and hazards that may be encountered are discussed.

In table 3 suggested tree and shrub species are given for the following uses: shade trees, street trees, hedges and screens, woodland plantings, windbreaks, and wildlife plantings. The plants are not listed in order of preference, and the list does not include all suitable trees or shrubs. Individual preference and advice of specialists will determine which species will be used. Soils have been placed in four environmental planting groups as follows:

ENVIRONMENTAL PLANTING GROUP 1.—In this group are soils that have properties generally favorable to good plant growth. Erosion is a hazard on the sloping soils. Plant-available water is less than optimum during dry periods in some soils, especially in the Dickinson, Cylinder, and Wadena soils that have coarse material at a depth of 32

inches or less. The steep and very steep Lester soils often lack adequate available water, especially on south-and southwest-facing slopes. Also, cultural operations are limited by the topography of the Lester soils. The Spillville soils are subject to flooding, but generally the floods are infrequent and of short duration. The surface layer of most of the soils in this group is slightly acid or medium acid unless limed.

ENVIRONMENTAL PLANTING GROUP 2.—In this group are wet soils, and some that are subject to ponding or to flooding. Maximum duration of standing water is a few days to a week, except during unusually wet periods (Marsh is an exception). Artificial drainage systems have been installed in many places to speed removal of excess water. Poor tilth is a problem at times, especially on soils that have a moderately fine textured surface layer. Collinwood soils have better natural drainage than the other soils in this group. The Biscay and Talcot soils that have gravel and sand at a depth of 32 inches or less have lower available water capacity than is typical for this group. The surface layer of a majority of these soils ranges from slightly acid to moderately alkaline.

ENVIRONMENTAL PLANTING GROUP 3.—The properties of soils in this group generally are favorable for plant growth, but the soils have excess lime at or near the surface. This inhibits growth of many kinds of trees and shrubs. Erosion is a serious hazard, and available water often is less than optimum because of rapid runoff. Cultural operations are limited by the topography of the steep and very steep soils. The surface layer is mildly alkaline or moderately alkaline.

ENVIRONMENTAL PLANTING GROUP 4.—Plant growth is limited in soils of this group by the lack of adequate available water during dry periods. Soil blowing is a hazard, and water erosion is a hazard on the sloping soils. Reaction of the surface layer generally is slightly acid or neutral, but it ranges to moderately alkaline.

Only a small part of Buena Vista County is wooded. Most of the natural stands of trees are along the Little Sioux River (fig. 17). Trees and shrubs, however, have been planted around most farmsteads to serve as windbreaks. Few merchantable timber products have been produced in the county. Most of the woodland is grazed and is managed mainly for pasture.

Windbreaks are effective in reducing the severity of the climate around a farmstead. They also provide other benefits, such as habitat for wildlife. Technical assistance in establishing and managing windbreaks or other plantings is available to landowners through the local office of the local Soil Conservation District (SCS) or from the State Conservation Commission (fig. 18).

Use of the Soils for Engineering [2]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, facilities for storing water, erosion-control structures, irrigation systems, drainage systems, building foundations and sewage disposal systems. The properties most important in engineering are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Depth to water table, depth to bedrock, and topography are also important.

[2] VOLNEY H. SMITH, assistant conservation engineer, Soil Conservation Service, helped prepare this section.

Figure 17.—**Area near Linn Grove in the northeastern part of the county. Wooded soils, mainly Storden and Lester, are along the Little Sioux River and its bordering side slopes. Note windbreaks around the homes and farmstead. Harvested cornfield in foreground is in an area of Galva silty clay loam. Storden and Lester soils are in areas of wooded side slopes.**

TABLE 3.—*Environmental planting groups*

Environmental planting group	Type of planting	
	Shade tree	Street tree
Group 1: Moderately coarse textured to moderately fine textured, somewhat poorly drained to somewhat excessively drained soils that have moderate or high available water capacity and are noncalcareous to a depth of at least 18 inches.	American basswood, honey locust, green ash, hackberry, sugar maple, and silver maple.	Green ash, hackberry, pin oak, and sugar maple.
Group 2: Medium textured or moderately fine textured, poorly drained or very poorly drained soils that have moderate or high available water capacity. Some of the soils are calcareous at or near the surface. Included are soils that have high organic-matter content.	Silver maple, hackberry, sycamore, and green ash.	Hackberry, American sycamore, and green ash.
Group 3: Medium-textured, somewhat excessively drained Storden soils that have high available water capacity and are calcareous within a depth of 10 inches.	Green ash, hackberry, and silver maple	Green ash and hackberry
Group 4: Coarse textured or moderately coarse textured, somewhat excessively drained soils that have low or very low available water capacity.	Scarlet oak, bur oak, hackberry, green ash, and silver maple.	Hackberry and green ash

[1] Not well suited to very poorly drained soils.

This information in this soil survey can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that help in the planning of farm drainage systems, farm ponds, irrigation systems, terraces, waterways, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, or other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that is useful in designing and maintaining specified engineering practices and structures.

Figure 18.—**Farmstead windbreaks, mainly on Galva and Sac soils.**

of soils and suitable trees or shrubs

Type of planting—Continued			
Hedge or screen	Woodland	Windbreak	Wildlife
Lilac, American cranberrybush, Tatarian honeysuckle, silky dogwood, arrowwood viburnum, and hawthorn.	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple, and poplars.	Eastern white pine, red pine, blue spruce, Norway spruce, Scotch pine, white spruce, European larch, eastern redcedar, green ash, hackberry, eastern cottonwood, Douglas-fir, Tatarian honeysuckle, Austrian pine, ponderosa pine, pin oak, Russian-olive, silver maple, and lilac.	Blackhaw, lilac, gray dogwood, alternate-leaf dogwood, autumn olive, Tatarian honeysuckle, American plum, and midwest Manchurian crabapple.
Northern white-cedar, silky dogwood, American cranberrybush, and Lombardy poplar.	Eastern cottonwood	Silver maple, poplars, laurel willow, American sycamore, green ash, hackberry [1], northern white-cedar, eastern redcedar[1], white spruce[1], and Norway spruce [1].	Red-osier dogwood, eastern redcedar, northern white-cedar, silky dogwood, and American cranberrybush.
Eastern redcedar, honeysuckle, Russian-olive, and Siberian peashrub.	Ponderosa pine, Austrian pine, Scotch pine, hackberry, poplars, and green ash.	Ponderosa pine, Austrian pine, green ash, hackberry, Russian-olive, eastern redcedar, and northern white-cedar.	American plum, Amur honeysuckle, Tatarian honeysuckle, Russian-olive, and eastern redcedar.
Eastern redcedar, Russian-olive, honeysuckle, lilac, and Siberian peashrub.	Eastern white pine, Scotch pine, European larch, and eastern redcedar.	Red pine, eastern white pine, Scotch pine, eastern redcedar, green ash, hackberry, Austrian pine, ponderosa pine, and Siberian peashrub.	Blackhaw, lilac, gray dogwood, alternate-leaf dogwood, and autumn olive.

6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs to make maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The engineering interpretations reported here can be useful for many purposes. It should be emphasized, however, that they do not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depth of the layers reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that are to be expected.

Information regarding the behavior and properties of the soils in Buena Vista County can be obtained from the section "Descriptions of the Soils" and from tables 4 and 5 in this section. The information in the tables was obtained and evaluated from field experience, field performance of the soils, and the results of engineering tests performed by the Iowa State Highway Commission.

Some terms used by the soil scientist may have special meaning in soil science and may be unfamiliar or have a different meaning to engineers. Many of these terms are defined in the Glossary at the back of this publication.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system used by SCS engineers, the Department of Defense, and others and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes—eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC: six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL-ML.

The AASHTO system is used in classifying soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest mineral soils for subgrade. If laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils (without group index numbers) is given in table 4 for all soils mapped in the survey area.

Estimated properties significant to engineering

Several estimated soil properties significant to engineering are given in table 4. Evaluations are made for the

typical profile of each soil series by layers sufficiently different from each other that each layer has unique significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for the specified soils and similar soils, and on experience with the same kinds of soils in other counties. In the following paragraphs are explanations of some of the columns in table 4.

Depth to seasonal high water table is the distance from the surface of the soil downward to the highest level reached in most years by ground water.

Soil texture is described in table 4 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index pertain to the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to the plastic state, and the liquid limit from the plastic to the liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index in table 4 are estimates.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 4 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount in the soil at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soil causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material that has this rating.

Engineering interpretations of the soils

The estimated interpretations in table 5 are based on the engineering properties of soils shown in table 4, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Buena Vista County. In table 5, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for drainage of cultivated areas and pasture, irrigation, pond reservoirs, embankments, and terraces and diversions. For those particular uses, table 5 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight, moderate,* and *severe. Slight* means soil properties generally are favorable for the rated use or, in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable, but they can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome that major soil reclamation and special design is required. For some uses, the rating of severe is divided to obtain ratings of *severe* and *very severe. Very severe* means one or more soil properties is so unfavorable for the particular use that overcoming the limitations is too difficult and costly to be practical.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms *slight, moderate,* and *severe.*

The following paragraphs present explanations of some of the columns in table 5.

Septic-tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, content of organic matter, slope, and, if the floor needs to be leveled, depth to bedrock. The soil properties that affect the embankment are the engineering properties of the embankment material, as interpreted from the Unified Soil Classification, and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 5 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than 6 feet. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, for which soil ratings are given in

table 5, have an all-weather surface expected to carry automobile traffic all year. These roads and streets have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface that generally is asphalt or concrete. These roads and streets are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are of less than 6 feet.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity, stability of the subgrade, and workability and quantity of cut-and-fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet; for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings without basements, for which the soils are given limitation ratings in table 5, are those that are not more than three stories high and are supported by foundation footings placed in undisturbed soils. The features that affect the rating of a soil for such swellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 5 provide guidance as to where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings take into account thickness of overburden and pressure of a seasonal high water table. The pressure of fines (material smaller than 0.074 millimeters that passes the No. 200 sieve) affecting the quality of the deposit is also considered in the ratings.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, when preparing a seedbed for example; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is the damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or to other permeable material.

Embankments, dikes, and levees for retention of water require soil material that is resistant to seepage and piping and has favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or presence of organic material in a soil are among the unfavorable factors.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage or depth to water table or bedrock.

Terraces and drainageways are low ridges constructed across the slope to intercept or divert runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Special features affecting highway construction [3]

Some soils in the county have features that cannot be fully accounted for in the engineering tables. These features affect highway construction and need further explanation.

Many of the soils in the western part of Buena Vista County formed in loess that was as much as 5 feet thick over glacial till. These nearly level to sloping soils are on uplands. On the more sloping hillsides the loess is thinner, and in places it is missing. In these places till is at the surface.

The nearly level soils that formed in loess on uplands, such as Primghar and Marcus, are classified A–7 (AASHTO) and OH, CL, or CH (Unified). The upper 12 inches or more of these soils is organic and therefore difficult to compact to good density, and the subsoil is more plastic and has high shrink-swell potential. Soils that formed in loess over till on sloping hillsides, such as those in the Sac series, have a thinner surface layer and a subsoil that is less plastic. The soils that formed in loess are readily eroded where runoff is rapid, and sodding, paving, or building of check dams is needed in gutters and ditches.

A seasonal high water table is perched above the till in places in soils that formed in loess over till. In places in the more nearly level soils or in soils in depressions, a shallow perched water table is above a plastic B horizon. In these

[3] Prepared by CLARE J. SCHROEDER, soils engineer, Iowa State Highway Commission.

TABLE 4.—*Estimates of soil properties*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The soils in referring to other series that appear in that column. Absence of data indicates that no

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification: Unified	Classification: AASHTO
	Feet	*Inches*			
Afton: 31	1–3	0–30	Silty clay loam	OH or CH	A–7–6 or A–7–5
		30–46	Silty clay loam	CH or CL	A–7–6
		46–60	Silty clay loam	CL or CH	A–7–6 or A–6
Biscay: 259	1–3	0–18	Clay loam	CL, OL, or OH	A–7–6
		18–35	Clay loam or sandy clay loam	CL	A–6
		35–60	Sand and gravel	SM–SW, SM or SC	A–1–b or A–2–4
Blue Earth: 511	[2] 0–3	0–16	Mucky silt loam	OH or MH	A–7–5 or A–7–6
		16–26	Silty clay loam	OH or CH	A–7–6 or A–7–5
		26–44	Silt loam	CL	A–6 or A–7
		44–60	Silt loam	CL	A–6 or A–7
Calco: 733	[3] 1–3	0–36	Silty clay loam	OL or CH	A–7–5 or A–7–6
		36–60	Silty clay loam	CL or CH	A–7–6
Canisteo: 507	1–3	0–23	Silty clay loam or clay loam	OH, CH, or MH	A–7–6 or A–7–5
		23–34	Clay loam	CL	A–6 or A–7–6
		34–60	Clay loam	CL	A–6 or A–7–6
Clarion: 138B, 138C2, 138D2	>5	0–16	Loam	CL or CL–ML	A–4 or A–6
		16–32	Loam	CL or CL–ML	A–4 or A–6
		32–60	Loam or clay loam	CL or CL–ML	A–4 or A–6
250B	>5	0–11	Silty clay loam	ML or CL	A–7–5 or A–7–6
		11–44	Clay loam	CL	A–6 or A–7–6
		44–60	Loam	CL or CL–ML	A–6 or A–4
Collinwood: 384, 384B, 384C	2–4	0–15	Silty clay loam or silty clay	OH, MH, or CH	A–7–6
		15–37	Silty clay	CH or MH	A–7–6
		37–60	Silty clay	CH or MH	A–7–6
*Colo: 133, 585B, C585. For Spillville parts of 585B and C585, see Spillville series.	[3] 1–3	0–48	Silty clay loam	CL, OH, or OL	A–7–6
		48–60	Silty clay loam	CL or CH	A–7–6
Cylinder: 203	2–4	0–16	Loam	CL	A–6 or A–7–6
		16–36	Loam or sandy clay loam	CL or SC	A–4 or A–6
		[4] 36–60	Sand and gravel	SP–SM, SC, or SM	A–1–b or A–2–4
202	2–4	0–20	Loam	CL	A–6 or A–7–5
		20–30	Loam or sandy clay loam	CL or SC	A–4 or A–6
		[5] 30–60	Sand and gravel	SP–SM, SC, or SM	A–1–b or A–2–4
Dickinson: 175B	>5	0–13	Fine sandy loam	SM, SC, or SM–SC	A–4 or A–2–4
		13–25	Fine sandy loam	SM, SC, or SM–SC	A–4 or A–2–4
		[6] 25–39	Loamy fine sand	SM or SM–SC	A–2–4
		39–60	Fine sand	SM, SP, or SM–SP	A–2–4 or A–3
Ely: 428B	2–3	0–29	Silty clay loam	CL or OL	A–7–6
		29–52	Silty clay loam	CL	A–7–6 or A–6
		52–60	Silt loam	CL	A–6
Estherville: 34B, 34C2	>5	0–13	Sandy loam	SM, SM–SC, or SC	A–2–4
		13–19	Sandy loam	SM, SM–SC, or SC	A–2–4
		[7] 19–60	Gravelly sand	SP, SM, or SC	A–1 or A–2–4
Everly: 577B, 577C, 577C2	>5	0–13	Clay loam	ML or CL	A–6 or A–7–6
		13–31	Clay loam	CL	A–6 or A–7–6
		31–60	Loam	CL	A–6 or A–7–6
Fill land: 504	1–3	0–60	([8])	([8])	([8])
Galva: 310, 310B, 310C2	>5	0–16	Silty clay loam	ML or CL	A–7–5 or A–7–6
		16–48	Silty clay loam	ML or CL	A–7–6
		48–60	Clay loam	CL	A–6 or A–7–6
T310	>5	0–17	Silty clay loam	ML or CL	A–7–5 or A–7–6

significant to engineering

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for estimate was made. The symbol > means greater than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)			*Inches per hour*	*Inches per inch of soil*	*pH*	
---	---	100	95–100	50–65	20–35	0.2–0.6	0.21–0.23	6.1–7.8	High.
---	---	100	95–100	45–60	20–35	0.2–0.6	0.18–0.20	7.4–8.4	High.
100	95–100	95–100	85–95	35–50	15–25	0.2–2.0	0.18–0.20	7.4–8.4	Moderate or high.
100	95–100	70–90	70–80	41–55	15–25	0.6–2.0	0.17–0.19	6.1–7.8	Moderate.
95–100	90–100	70–90	50–75	30–40	11–20	0.6–2.0	0.16–0.18	6.6–7.8	Moderate.
75–95	60–80	20–45	5–25	[1] NP–20	NP–10	6.0–20	0.02–0.04	7.9–8.4	Very low or none.
100	95–100	95–100	90–100	50–70	20–35	0.6–2.0	0.23–0.25	7.4–8.4	High.
100	95–100	90–100	75–95	50–70	25–40	0.2–2.0	0.21–0.23	7.4–8.4	Moderate or high.
95–100	90–100	80–90	60–85	35–50	11–25	0.6–2.0	0.20–0.22	7.4–8.4	Moderate.
95–100	90–100	80–90	60–85	35–50	11–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
---	100	90–100	85–100	41–60	15–30	0.2–0.6	0.21–0.23	7.4–8.4	High.
---	100	90–100	80–100	41–55	15–30	0.2–0.6	0.18–0.20	7.4–8.4	Moderate or high.
100	95–100	85–95	70–90	50–65	15–30	0.6–2.0	0.19–0.21	7.4–8.4	Moderate or high.
95–100	95–100	85–95	60–80	30–50	15–30	0.6–2.0	0.16–0.18	7.4–8.4	Moderate or high.
95–100	95–100	75–85	55–80	30–45	11–20	0.6–2.0	0.14–0.16	7.4–8.4	Moderate.
95–100	95–100	75–90	50–75	25–40	5–20	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
95–100	90–100	75–90	50–75	25–40	5–20	0.6–2.0	0.17–0.19	6.1–7.3	Moderate.
90–100	85–100	75–90	50–75	25–40	5–20	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
95–100	100	95–100	90–100	41–50	11–20	0.6–2.0	0.21–0.23	6.6–7.3	Moderate or high.
95–100	95–100	85–95	70–90	35–45	11–20	0.6–2.0	0.16–0.18	6.6–7.3	Moderate.
90–100	85–100	75–85	50–80	25–40	5–20	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
100	95–100	95–100	90–100	50–65	15–30	0.06–0.2	0.16–0.18	6.1–7.3	High.
100	95–100	95–100	90–100	50–65	15–30	0.06–0.2	0.13–0.15	6.1–8.4	High.
100	95–100	95–100	90–100	50–65	15–30	0.06–0.2	0.14–0.16	7.4–8.4	High.
---	100	90–100	80–100	41–60	15–40	0.2–0.6	0.21–0.23	6.1–7.3	High.
---	100	90–100	90–100	41–60	15–40	0.2–0.6	0.18–0.20	6.6–8.4	High.
100	90–100	70–85	50–75	30–50	11–25	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
95–100	80–100	55–75	40–60	30–40	5–20	0.6–2.0	0.16–0.18	6.1–7.3	Moderate.
75–95	60–80	20–40	5–25	NP–20	NP–10	6.0–20	0.02–0.04	6.6–8.4	Very low or none.
100	90–100	70–85	50–75	30–50	11–25	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
95–100	80–100	55–75	40–60	30–40	5–20	0.6–2.0	0.16–0.18	6.6–7.3	Moderate.
75–95	60–80	20–40	5–25	NP–20	NP–10	6.0–20	0.02–0.04	6.6–8.4	Very low or none.
---	100	85–95	35–60	15–30	5–10	2.0–6.0	0.16–0.18	5.6–7.3	Low.
---	100	85–95	35–60	15–30	5–10	2.0–6.0	0.15–0.17	5.6–6.5	Low.
---	100	80–95	15–30	10–30	5–10	2.0–6.0	0.08–0.10	6.1–6.5	Very low.
---	100	70–90	2–20	NP–20	NP–5	6.0–20	0.05–0.07	6.6–8.4	Very low or none.
---	100	95–100	95–100	41–50	11–25	0.6–2.0	0.21–0.23	5.6–6.5	Moderate or high.
---	100	95–100	95–100	35–45	11–25	0.6–2.0	0.18–0.20	6.1–7.3	Moderate or high.
---	100	95–100	90–100	30–40	11–20	0.6–2.0	0.20–0.22	6.6–8.4	Moderate.
90–100	80–95	50–75	15–35	25–35	2–10	2.0–6.0	0.13–0.15	5.6–7.3	Low.
85–100	75–95	35–60	15–35	20–30	2–10	2.0–6.0	0.12–0.14	5.6–7.3	Low.
70–90	60–80	10–40	2–20	NP–20	NP–10	6.0–20	0.02–0.04	7.4–8.4	Very low or none.
100	95–100	85–95	65–80	30–50	11–20	0.6–2.0	0.17–0.19	5.6–6.5	Moderate.
95–100	95–100	85–95	70–90	30–50	15–30	0.6–2.0	0.15–0.19	6.1–8.4	Moderate.
90–100	85–95	75–85	60–80	30–50	15–30	0.6–2.0	0.17–0.19	7.4–8.4	Moderate.
([8])	([8])	([8])	([8])	([8])	([8])	([8])	([8])	6.6–8.4	Moderate.
---	100	95–100	90–100	41–50	11–25	0.6–2.0	0.21–0.23	5.6–6.5	Moderate or high.
---	100	95–100	90–100	41–50	15–30	0.6–2.0	0.18–0.20	6.1–7.3	Moderate or high.
95–100	90–100	80–90	65–80	35–45	11–20	0.6–2.0	0.14–0.16	7.4–8.4	Moderate.
---	100	95–100	90–100	41–50	11–25	0.6–2.0	0.21–0.23	6.1–7.3	Moderate or high.

TABLE 4.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
		17–43	Silty clay loam	ML or CL	A–7–6
		43–50	Silt loam	CL	A–7–6 or A–6
		50–60	Gravelly sandy clay loam	CL, SC, or SM–SC	A–4 or A–6
		60–72	Gravelly fine sand	SM–SP, SM, or SC	A–1–b or A–2–4
Gravel pits: 501	(8)	0–60	Gravel or sand	(8)	(8)
Harps: 95	1–3	0–16	Loam	CL, CH, or OH	A–6, A–7–5, or A–7–6
		16–35	Loam	CL	A–6 or A–7–6
		35–60	Loam	CL	A–6 or A–7–6
Lanyon: 606	[2] 0–3	0–13	Silty clay loam	OH or CH	A–7–6
		13–21	Silty clay	CH	A–7–6
		21–60	Silty clay loam	CH	A–7–6
Lester: 236F, 236G	>5	0–9	Loam	ML or CL	A–7–6 or A–6
		9–31	Clay loam	CL	A–6 or A–7–6
		31–60	Clay loam or loam	CL or ML	A–4 or A–6
Marcus: 92	1–3	0–17	Silty clay loam	OH or CH	A–7–5 or A–7–6
		17–44	Silty clay loam	CH or CL	A–7–6
		44–57	Silt loam	CL	A–7–6 or A–6
		57–60	Loam	CL	A–6 or A–7–6
Marsh: 354	(9)	(10)	(10)	OH, OH–ML, or PT	A–7–5 or A–7–6
Millington: C458	[3] 0–3	0–72	Loam or silt loam	CL	A–6
Nicollet: 55	2–4	0–20	Loam or clay loam	CL	A–6 or A–7–6
		20–34	Clay loam	CL	A–6 or A–7–6
		34–60	Loam	CL or ML	A–4 or A–6
251	2–4	0–22	Silty clay loam or clay loam	ML or CL	A–7–6
		22–36	Clay loam	CL	A–6 or A–7–6
		36–60	Loam	CL or ML	A–4 or A–6
Okoboji: 6	[2] 0–3	0–34	Silty clay loam	OH, CH, or MH	A–7–6 or A–7–5
		34–58	Silty clay or silty clay loam	CH or MH	A–7–6 or A–7–5
		58–76	Silty clay loam	CH or CL	A–7–6 or A–7–5
Primghar: 91, 91B	2–4	0–18	Silty clay loam	CH, OH, or CL	A–7–5 or A–7–6
		18–48	Silty clay loam	CL or CH	A–7–6
		48–60	Silt loam	CL or ML	A–7–6 or A–6
Rolfe: 274	[2] 0–3	0–17	Silt loam	OL or CL	A–6
		17–47	Silty clay or clay loam	CH	A–7–6
		47–60	Loam	CL	A–6 or A–7–6
Sac: 77B, 77C2	>5	0–12	Silty clay loam	ML or CL	A–7–5 or A–7–6
		12–28	Silty clay loam	CL or ML	A–7–6
		28–38	Clay loam or loam	CL	A–6
		38–60	Loam	CL	A–6
78B, 78C2	>5	0–13	Silty clay loam	ML or CL	A–7–5 or A–7–6
		13–27	Silty clay loam	CL or ML	A–7–6
		27–33	Clay loam	CL	A–6 or A–7–6
		33–60	Clay loam	CL	A–6 or A–7–6
Salida: 73C, 73D	>5	0–7	Gravelly sandy loam	SM–SC, SC, or SM	A–2–4 or A–1–b
		7–12	Gravelly sandy loam	SM–SC, SC, or SM	A–2–4 or A–1–b
		[11] 12–60	Gravelly sand	SM–SP or SM	A–1–b
Spicer: 32	1–3	0–23	Silty clay loam	OH or CH	A–7–5 or A–7–6
		23–41	Silty clay loam	CH or CL	A–7–6
		41–54	Silt loam	CL	A–7–6 or A–6
		54–60	Loam	CL	A–6
Spillville: 485, 485B	[6] 2–4	0–45	Loam	CL or OL	A–6 or A–4
		45–60	Loam	CL or ML	A–6 or A–4
Storden: 62C, 62D, 62E, 62F, 62G.	>5	0–60	Loam	CL or CL–ML	A–4 or A–6

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)						
						Inches per hour	*Inches per inch of soil*	*pH*	
---	100	95–100	90–100	41–50	15–30	0.6–2.0	0.18–0.20	6.6–7.3	Moderate or high.
---	100	95–100	90–100	35–45	15–25	0.6–2.0	0.20–0.22	7.4–7.8	Moderate or high.
95–100	80–100	50–80	40–60	25–40	5–15	0.6–6.0	0.14–0.16	7.4–7.8	Moderate or low.
75–90	50–75	30–50	2–20	NP–20	NP–10	6.0–20	0.02–0.04	7.9–8.4	Very low or none.
[8]	[8]	[8]	[8]	[8]	[8]	[8]	[8]	7.9–8.4	Very low or none.
100	95–100	80–90	65–80	41–60	20–35	0.6–2.0	0.20–0.22	7.9–8.4	Moderate or high.
95–100	95–100	80–90	65–80	35–50	20–30	0.6–2.0	0.17–0.19	7.9–8.4	Moderate or high.
95–100	90–100	70–90	50–90	35–45	15–25	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
---	100	90–100	80–100	50–65	30–40	0.2–0.6	0.21–0.23	7.4–8.4	High.
100	95–100	95–100	90–100	50–65	30–40	0.06–0.2	0.13–0.15	7.9–8.4	High.
100	95–100	85–100	75–95	41–60	25–35	0.2–0.6	0.14–0.16	7.9–8.4	High.
95–100	95–100	80–90	60–80	35–45	11–20	0.6–2.0	0.20–0.22	5.6–6.5	Moderate.
95–100	90–100	80–90	60–80	35–45	11–20	0.6–2.0	0.15–0.19	5.1–7.3	Moderate.
90–100	85–100	70–80	50–75	30–40	5–15	0.6–2.0	0.16–0.18	7.9–8.4	Moderate.
---	100	95–100	90–100	50–65	20–35	0.2–0.6	0.21–0.23	6.1–7.3	High.
---	100	95–100	90–100	45–60	20–35	0.2–0.6	0.18–0.20	6.6–8.4	High.
---	100	95–100	85–95	35–45	15–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate or high.
90–100	85–100	80–90	50–75	30–40	15–25	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
[10]	[10]	---	[10]	---	---	[8]	[8]	[10]	[10]
100	95–100	75–90	55–80	30–40	11–20	0.6–2.0	0.19–0.21	7.4–8.4	Moderate.
95–100	95–100	85–95	60–80	35–50	15–25	0.6–2.0	0.19–0.21	6.1–7.3	Moderate.
95–100	90–100	85–95	60–80	35–50	15–25	0.6–2.0	0.18–0.20	6.1–7.8	Moderate.
90–100	85–100	75–85	55–80	30–40	5–15	0.6–2.0	0.17–0.19	7.4–8.4	Moderate.
100	95–100	90–95	65–80	41–50	15–25	0.6–2.0	0.20–0.22	6.6–7.3	Moderate or high.
95–100	90–100	85–95	60–80	35–50	15–25	0.6–2.0	0.16–0.18	6.6–7.3	Moderate.
90–100	85–100	75–85	55–80	30–40	5–15	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
---	100	85–95	80–95	50–70	25–40	0.2–0.6	0.21–0.23	6.6–7.8	High.
100	95–100	85–95	80–95	50–65	20–40	0.2–0.6	0.16–0.18	6.6–8.4	High.
100	95–100	85–95	80–95	41–60	15–30	0.2–0.6	0.16–0.18	7.4–8.4	High.
---	100	95–100	90–100	45–60	20–35	0.6–2.0	0.21–0.23	5.6–6.5	High.
---	100	95–100	90–100	41–60	20–35	0.2–2.0	0.18–0.20	6.1–8.4	High.
---	100	95–100	70–100	35–50	15–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate.
100	95–100	90–100	80–95	30–40	11–20	0.6–2.0	0.22–0.24	5.6–7.3	Moderate.
100	95–100	90–100	75–95	50–70	25–40	0.06–0.2	0.13–0.15	6.1–7.3	High.
95–100	90–100	75–90	55–75	30–45	15–25	0.2–2.0	0.17–0.19	6.6–8.4	Moderate or high.
---	100	95–100	90–100	41–50	15–25	0.6–2.0	0.20–0.22	5.6–6.5	Moderate or high.
---	100	95–100	90–100	41–50	15–25	0.6–2.0	0.18–0.20	6.1–7.3	Moderate or high.
95–100	90–100	70–85	65–80	30–40	11–20	0.6–2.0	0.16–0.18	6.6–7.8	Moderate.
90–100	85–95	70–85	60–80	30–40	11–20	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
---	100	95–100	90–100	41–50	15–25	0.6–2.0	0.20–0.22	5.6–6.5	Moderate or high.
---	100	95–100	90–100	41–50	15–25	0.6–2.0	0.18–0.20	6.1–7.3	Moderate or high.
95–100	90–100	70–85	65–80	35–45	11–20	0.6–2.0	0.16–0.18	7.4–7.8	Moderate.
90–100	85–98	70–85	55–70	35–45	11–20	0.6–2.0	0.14–0.16	7.9–8.4	Moderate.
80–90	70–80	30–50	15–30	10–25	2–8	6.0–20	0.10–0.12	6.1–8.4	Low.
80–90	70–80	25–45	12–30	10–25	2–8	6.0–20	0.07–0.09	7.9–8.4	Low.
75–90	50–75	25–40	5–25	NP–20	NP–8	6.0–20	0.02–0.04	7.9–8.4	Very low or none.
---	100	95–100	90–100	50–65	20–35	0.6–2.0	0.21–0.23	7.9–8.4	High.
---	100	95–100	90–100	45–60	20–35	0.6–2.0	0.18–0.20	7.9–8.4	High.
---	100	95–100	85–95	35–45	15–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate or high.
90–100	85–100	80–90	50–75	30–40	15–25	0.6–2.0	0.17–0.19	7.9–8.4	Moderate.
100	95–100	75–90	55–80	30–40	5–15	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
100	95–100	75–90	55–80	30–40	5–15	0.6–2.0	0.17–0.19	7.4–8.4	Moderate.
90–100	85–100	75–90	55–75	25–40	5–15	0.6–2.0	0.17–0.19	7.4–8.4	Moderate.

TABLE 4.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification	
				Unified	AASHTO
	Feet	*Inches*			
Talcot: 559	1–3	0–18	Clay loam	OH or CL	A–7–5 or A–7–6
		18–38	Clay loam or loam	CL	A–6 or A–7–6
		[4] 38–60	Gravelly sand	SM or SP–SM	A–1–b or A–2–4
558	1–3	0–19	Clay loam	OH or CL	A–7–5 or A–7–6
		19–30	Clay loam or loam	CL	A–6 or A–7–6
		[5] 30–60	Sand and gravel	SP–SM or SM	A–1–b or A–2–4
Terril: 27C	>5	0–24	Loam or clay loam	OL, CL, or CL–ML	A–6 or A–4
		24–60	Clay loam or loam	CL or CL–ML	A–6 or A–4
Wacousta: 506	[2] 0–3	0–7	Mucky silt loam	OL or OH	A–7–5 or A–7–6
		7–15	Silty clay loam	CL or CH	A–6 or A–7–6
		15–60	Silt loam or silty clay loam	CL	A–6
Wadena: 308B	>5	0–18	Loam	ML or CL	A–4 or A–6
		18–36	Loam or sandy clay loam	CL or SC	A–4 or A–6
		[4] 36–60	Sand and gravel	SP–SM or SM	A–1–b or A–2–4
108, 108B, 108C2	>5	0–14	Loam	CL–ML or CL	A–4 or A–6
		14–28	Loam or sandy clay loam	CL or SC	A–4 or A–6
		[5] 28–60	Sand and gravel	SP–SM or SM	A–1–b or A–2–4
Waldorf: 390	1–3	0–24	Silty clay loam or silty clay	OH, MH, or CH	A–7–6
		24–42	Silty clay	CH or MH	A–7–6
		42–60	Silty clay	CH or MH	A–7–6
Webster: 107	1–3	0–18	Silty clay loam or clay loam	OH or MH	A–7–6 or A–7–5
		18–36	Clay loam or loam	CL or CH	A–6 or A–7–6
		36–60	Loam	CL	A–6 or A–7–6

[1] Nonplastic.
[2] Subject to ponding of water on the surface.
[3] Subject to flooding.
[4] Depth to sand and gravel ranges from 32 to 40 inches.
[5] Depth to sand and gravel ranges from 24 to 32 inches.
[6] Depth to sand or loamy sand ranges from 20 to 42 inches.

TABLE 5.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in the series is made up of two or more kinds of soil. The soils in such to other series that

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Afton: 31	Severe: seasonal high water table; moderately slow permeability.	Severe: high organic-matter content in surface layer; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained; high shrink-swell potential; high organic-matter content; low strength.	Severe: poorly drained; frequent high water table at a depth of 1 to 3 feet.	Severe: poorly drained; frequent high water table; high shrink-swell potential.
Biscay: 259	Severe: seasonal high water table; rapid permeability in substratum; hazard of contaminating ground water.	Severe: substratum too porous to hold water; seasonal high water table; hazard of contaminating ground water.	Severe: seasonal high water table; rapid permeability in sand and gravel substratum; hazard of contaminating ground water.	Severe: poorly drained.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; sand and gravel at a depth of 32 to 40 inches.	Severe: poorly drained; seasonal high water table; sand and gravel at a depth of 32 to 40 inches; moderate shrink-swell potential.

significant to engineering—Continued

Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
						Inches per hour	*Inches per inch of soil*	*pH*	
100	95–100	75–90	70–85	41–55	15–25	0.6–2.0	0.17–0.19	7.4–8.4	Moderate or high.
95–100	90–100	70–85	55–75	35–50	15–25	0.6–2.0	0.16–0.18	7.9–8.4	Moderate.
75–95	60–80	20–45	5–20	NP–20	NP–6	6.0–20	0.02–0.04	7.9–8.4	Very low or none.
100	95–100	75–90	70–85	41–55	15–25	0.6–2.0	0.17–0.19	7.4–8.4	Moderate or high.
95–100	90–100	70–85	55–75	35–50	15–25	0.2–2.0	0.16–0.18	7.9–8.4	Moderate.
75–95	60–80	20–45	5–25	NP–20	NP–6	6.0–20	0.02–0.04	7.9–8.4	Very low or none.
100	95–100	70–90	60–80	25–40	5–15	0.6–2.0	0.18–0.20	6.1–7.3	Moderate.
100	95–100	70–90	60–80	25–40	5–15	0.6–2.0	0.17–0.19	6.1–7.3	Moderate.
---	100	90–100	80–95	45–70	20–35	0.6–2.0	0.23–0.25	6.1–7.3	Moderate.
100	95–100	85–100	75–95	41–60	20–35	0.2–2.0	0.21–0.23	6.1–7.3	Moderate or high.
95–100	90–100	80–90	60–85	30–40	15–25	0.6–2.0	0.20–0.22	7.4–8.4	Moderate.
100	90–100	70–85	50–75	30–40	5–15	2.0–6.0	0.20–0.22	6.1–7.3	Moderate.
95–100	80–100	60–80	40–60	30–40	5–15	2.0–6.0	0.16–0.18	6.1–7.3	Moderate or low.
75–95	60–80	40–60	2–20	NP–20	NP–6	6.0–20	0.02–0.04	7.4–8.4	Very low or none.
100	90–100	70–85	50–75	30–40	5–15	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
95–100	80–100	60–80	40–60	30–40	5–15	0.6–2.0	0.16–0.18	6.1–7.3	Moderate or low.
75–95	60–80	40–60	2–20	NP–20	NP–6	6.0–20	0.02–0.04	7.4–8.4	Very low or none.
100	95–100	95–100	90–100	50–70	15–30	0.2–0.6	0.16–0.18	6.1–7.3	High.
100	95–100	95–100	90–100	50–70	15–30	0.2–0.6	0.14–0.16	6.1–8.4	High.
100	95–100	95–100	90–100	50–70	15–30	0.2–0.6	0.11–0.13	7.4–8.4	High.
100	95–100	85–95	70–90	50–65	15–30	0.6–2.0	0.19–0.21	6.1–7.3	High.
95–100	95–100	85–95	60–80	35–50	15–30	0.2–2.0	0.17–0.19	6.6–8.4	Moderate or high.
95–100	90–100	75–85	50–75	30–45	11–20	0.6–2.0	0.16–0.18	7.9–8.4	Moderate.

[7] Depth to sand and gravel ranges from 15 to 30 inches.
[8] Variable.
[9] Covered with water most of the time.
[10] Not determined.
[11] Depth to sand and gravel ranges from 7 to 18 inches.

engineering properties of the soils

mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring appear in that column]

Suitability as source of— Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Soil features affecting— Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: poorly drained; high organic-matter content; high shrink-swell potential; low strength.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderately slow permeability; high organic-matter content.	High organic-matter content to a depth of 2 feet or more; wet in places; high shrink-swell potential; fairly stable.	Poorly drained; frequent high water table; moderately slow permeability; tile function well.	High available water capacity; medium to slow intake rate; seasonal high water table; drainage needed.	Not needed.
Poor: poorly drained; seasonal high water table at a depth of 1 to 3 feet; sand and gravel with good bearing capacity and shear strength.	Fair to poor: many areas contain considerable fines; seasonal high water table.	Poor: poorly drained.	Porous sand and gravel substratum; nearly level.	High organic-matter content to a depth of about 2 feet; substratum stable but pervious.	Poorly drained; seasonal high water table; tile drains function well, but underlying sand and gravel hinder installation in places.	Moderate to high available water capacity; medium intake rate.	Not needed.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary land fill	Local roads and streets	Shallow excavations	Dwellings without basements
Blue Earth: 511	Severe: seasonal high water table; subject to ponding.	Severe: high organic-matter content in surface layer; moderate to moderately slow permeability; seasonal high water table.	Severe: seasonal high water table.	Severe: very poorly drained; subject to ponding; low strength.	Very severe: very poorly drained; frequent high water table at a depth of 0 to 3 feet; subject to ponding.	Very severe: very poorly drained; frequent high water table; subject to ponding.
Calco: 733	Severe: seasonal high water table; subject to flooding; moderately slow permeability.	Severe: moderately slow permeability; seasonal high water table; subject to flooding; high organic-matter content.	Severe: subject to flooding; seasonal high water table.	Severe: poorly drained; subject to flooding; low strength.	Very severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; subject to flooding.	Very severe: poorly drained; seasonal high water table; subject to flooding.
Canisteo: 507	Severe: seasonal high water table.	Severe: seasonal high water table; high organic-matter content.	Severe: seasonal high water table.	Severe: poorly drained.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet.	Severe: poorly drained; seasonal high water table.
Clarion:						
138B	Slight	Moderate: slopes of 2 to 5 percent.	Slight [1]	Slight	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained.
138C2	Slight	Severe: slopes of 5 to 9 percent.	Slight [1]	Slight	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained.
138D2	Moderate: slopes of 9 to 14 percent.	Severe: slopes of 9 to 14 percent.	Slight [1]	Moderate: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: very poorly drained; subject to ponding; high organic-matter content in surface layer; low strength.	Unsuited: no sand or gravel.	Poor: very poorly drained.	Nearly level; moderate to moderately slow permeability; subject to ponding.	Poor workability and compaction; high organic-matter content in surface layer; frequent high water table.	Very poorly drained; frequent high water table; subject to ponding; moderate to moderately slow permeability; tile drains function well; open intake or surface drainage needed; deep cuts needed in places for outlets.	High to very high available water capacity; medium intake rate; frequent high water table; drainage needed.	Not needed.
Poor: poorly drained; low strength.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderately slow permeability unless compacted; high organic-matter content.	High organic-matter content to a depth of about 3 feet; fair to poor stability; poor workability; poor for embankment foundations.	Poorly drained; seasonal high water table; subject to frequent flooding in places; moderately slow permeability; tile drains function well, but outlets are submerged in places.	High available water capacity; medium intake rate; seasonal high water table; subject to frequent flooding in places.	Not needed.
Poor: poorly drained.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderate permeability unless compacted; seasonal high water table.	Fair stability and compaction below the surface layer; slow permeability where compacted.	Poorly drained; seasonal high water table; moderate permeability; tile drains function well if outlets are adequate.	High available water capacity; medium intake rate; seasonal high water table; drainage needed.	Not needed.
Good	Unsuited: no sand or gravel.	Good: moderate to high organic-matter content in surface layer.	Moderate permeability unless compacted; pockets of sand and gravel in places; slopes of 2 to 5 percent.	Good stability; stones or boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent.	Complex, short, irregular slopes in many places; stones or boulders in places; slopes of 2 to 5 percent.
Good	Unsuited: no sand or gravel.	Good: moderately low to moderate organic-matter content in surface layer.	Moderate permeability unless compacted; pockets of sand and gravel in places; slopes of 5 to 9 percent.	Good stability; stones or boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 5 to 9 percent.	Complex, short, irregular slopes in many places; stones or boulders in places; slopes of 5 to 9 percent.
Good	Unsuited: no sand or gravel.	Fair: slopes of 9 to 14 percent; moderately low to moderate organic-matter content in surface layer.	Moderate permeability unless compacted; pockets of sand and gravel in places; slopes of 9 to 14 percent.	Good stability; stones or boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 9 to 14 percent.	Complex, short, irregular slopes in many places; stones or boulders in places; slopes of 9 to 14 percent.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for— Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Clarion—Continued						
250B	Slight	Moderate: slopes of 2 to 5 percent.	Slight [1]	Slight	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained.
Collinwood: 384	Severe: slow permeability; seasonal high water table at a depth of 2 to 4 feet.	Severe: seasonal high water table.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; heavy silty clay loam and silty clay.	Severe: high shrink-swell potential; low strength.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.	Severe: low strength; high shrink-swell potential.
384B	Severe: slow permeability; seasonal high water table at a depth of 2 to 4 feet.	Severe: seasonal high water table.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; heavy silty clay loam and silty clay.	Severe: high shrink-swell potential; low strength.	Moderate to severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.	Severe: low strength; high shrink-swell potential.
384C	Severe: slow permeability; seasonal high water table at a depth of 2 to 4 feet.	Severe: slopes of 5 to 9 percent; seasonal high water table.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; heavy silty clay loam and silty clay.	Severe: high shrink-swell potential; low strength.	Moderate to severe: somewhat poorly drained; slopes of 5 to 9 percent; seasonal high water table.	Severe: low strength; high shrink-swell potential.
*Colo: 133, 585B. For Spillville part of 585B, see Spillville series.	Severe: seasonal high water table; subject to flooding.	Severe: seasonal high water table; subject to flooding; high organic-matter content.	Severe: seasonal high water table; subject to flooding.	Severe: poorly drained; subject to flooding; high shrink-swell potential.	Very severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; subject to flooding.	Very severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; subject to flooding; high compressibility; uneven consolidation.
C585. For Spillville part, see Spillville series.	Severe: subject to frequent flooding; seasonal high water table.	Severe: subject to frequent flooding; seasonal high water table; high organic-matter content.	Severe: subject to frequent flooding; seasonal high water table.	Severe: poorly drained; subject to frequent flooding; high shrink-swell potential.	Very severe: poorly drained; frequent high water table at a depth of 0 to 3 feet; subject to frequent flooding.	Very severe: poorly drained; frequent high water table at a depth of 0 to 3 feet; subject to frequent flooding.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Good	Unsuited: no sand or gravel.	Fair: moderate to high organic-matter content in surface layer; moderately fine texture.	Moderate permeability unless compacted; pockets of sand and gravel in places; slopes of 2 to 5 percent.	Good stability; stones or boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent.	Features favorable; slopes of 2 to 5 percent.
Poor: low strength; high shrink-swell potential.	Unsuited: no sand or gravel.	Fair to poor: high organic-matter content in surface layer; fine texture.	Nearly level; slow permeability; seasonal high water table at a depth of 2 to 4 feet.	Fair stability; poor compaction; high shrink-swell potential.	Somewhat poorly drained; slow permeability; tile drains do not function well in places, but some areas benefit from tile drainage.	High available water capacity; slow intake rate; nearly level.	Not needed.
Poor: low strength; high shrink-swell potential.	Unsuited: no sand or gravel.	Fair to poor: fine texture; moderate to high organic-matter content in surface layer.	Slow permeability; slopes of 2 to 5 percent.	Fair stability; poor compaction; high shrink-swell potential.	Somewhat poorly drained; slopes of 2 to 5 percent; not needed in most places.	High available water capacity; slow intake rate; slopes of 2 to 5 percent.	Clayey subsoil; difficult to establish plants in channels without adding topsoil; slopes of 2 to 5 percent.
Very poor: low strength; high shrink-swell potential.	Unsuited: no sand or gravel.	Fair to poor	Slow permeability; slopes of 5 to 9 percent.	Fair stability; poor compaction; high shrink-swell potential.	Somewhat poorly drained; slopes of 5 to 9 percent; not needed.	High available water capacity; slow intake rate; slopes of 5 to 9 percent.	Clayey subsoil; difficult to establish plants in channels without adding topsoil; slopes of 5 to 9 percent.
Poor: poorly drained; high organic-matter content; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained.	Moderately slow permeability; seasonal high water table.	High organic-matter content to a depth of about 3 feet; fair to poor stability; poor workability; poor for embankment foundations.	Poorly drained; seasonal high water table; moderately slow permeability; tile drains function well, but outlets are submerged in places; subject to frequent flooding in places.	High available water capacity; medium intake rate; seasonal high water table; subject to flooding.	Not needed where slopes are 0 to 2 percent. Diversion terraces are needed in places where slopes are 2 to 5 percent.
Poor: poorly drained; subject to frequent flooding; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained; subject to frequent flooding.	Moderately slow permeability; seasonal high water table; subject to frequent flooding.	High organic-matter content to a depth of about 3 feet; fair to poor stability; poor workability; poor for embankment foundations.	Poorly drained; seasonal high water table; moderately slow permeability; subject to frequent flooding.	High available water capacity; medium intake rate; seasonal high water table; subject to frequent flooding.	Not needed.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for— Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Cylinder: 203	Moderate: seasonal high water table at a depth of 2 to 4 feet; rapid permeability in substratum; hazard of contaminating ground water.	Severe: sand and gravel in substratum too porous to hold water; seasonal high water table at a depth of 2 to 4 feet; hazard of contaminating ground water.	Severe: rapid permeability in substratum; seasonal high water table at a depth of 2 to 4 feet; hazard of contaminating ground water.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; sand and gravel at a depth of 32 to 40 inches.	Moderate: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.
202	Moderate: seasonal high water table at a depth of 2 to 4 feet; rapid permeability in substratum; hazard of contaminating ground water.	Severe: sand and gravel in substratum too porous to hold water; seasonal high water table at a depth of 2 to 4 feet; hazard of contaminating ground water.	Severe: rapid permeability in substratum; seasonal high water table at a depth of 2 to 4 feet; hazard of contaminating ground water.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; sand and gravel at a depth of 24 to 32 inches.	Moderate: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.
Dickinson: 175B	Slight: rapid permeability in substratum allows effluent to travel long distances in places.	Severe: rapid permeability in substratum; subsoil and substratum too porous to hold water.	Severe: rapid permeability in substratum; hazard of contaminating ground water.	Slight	Slight: somewhat excessively drained; seasonal water table below a depth of 5 feet.	Slight: somewhat excessively drained.
Ely: 428B	Moderate to severe: seasonal high water table at a depth of 2 to 5 feet.	Moderate: slopes of 2 to 5 percent; high organic-matter content in surface layer.	Severe: seasonal high water table at a depth of 2 to 5 feet.	Moderate: somewhat poorly drained; moderate to high shrink-swell potential.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 5 feet.	Moderate to severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 5 feet; moderate to high shrink-swell potential.
Estherville: 34B	Slight: hazard of contaminating ground water.	Severe: sand and gravel at a depth of 15 to 30 inches; substratum too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability in substratum; severe hazard of contaminating ground water.	Slight	Slight to moderate: somewhat excessively drained; seasonal water table below a depth of 5 feet; sand and gravel at a depth of 15 to 30 inches.	Slight: somewhat excessively drained; low shrink-swell potential; sand and gravel at a depth of 15 to 30 inches.
34C2	Moderate: slopes of 5 to 9 percent; severe hazard of contaminating ground water.	Severe: sand and gravel at a depth of 15 to 30 inches; substratum too porous to hold water; severe hazard of contaminating ground water; slopes of 5 to 9 percent.	Severe: rapid permeability in substratum; severe hazard of contaminating ground water.	Slight	Slight to moderate: somewhat excessively drained; seasonal water table below a depth of 5 feet; sand and gravel at a depth of 15 to 30 inches.	Slight: somewhat excessively drained; low shrink-swell potential.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair to good above a depth of 3 feet. Good below a depth of 3 feet: somewhat poorly drained.	Fair to poor: many areas contain considerable fines; seasonal high water table at a depth of 2 to 4 feet.	Good: medium texture; moderate to high organic-matter content in surface layer.	Porous sand and gravel substratum; nearly level; seasonal high water table at a depth of 2 to 4 feet.	Good stability, especially in substratum; pervious substratum.	Somewhat poorly drained; tile drains generally not needed; underlying sand and gravel hinder installation in places.	Moderate to high available water capacity; medium intake rate.	Not needed.
Fair to good above a depth of 2 to 2½ feet. Good below a depth of 2 to 2½ feet: somewhat poorly drained.	Fair to poor: many areas contain considerable fines; seasonal high water table at a depth of 2 to 4 feet.	Good: medium texture; moderate to high organic-matter content in surface layer.	Porous sand and gravel substratum; nearly level; seasonal high water table at a depth of 2 to 4 feet.	Good stability, especially in substratum; pervious substratum.	Somewhat poorly drained; tile drains generally not needed; underlying sand and gravel hinder installation in places.	Low to moderate available water capacity; medium intake rate; rapid permeability in substratum limits effective irrigation to a depth of 2 to 3 feet.	Not needed.
Good	Fair to poor: sand; many areas contain considerable fines.	Good to a depth of 1 to 1½ feet. Fair to poor below a depth of 1 to 1½ feet.	Rapid permeability in substratum; compaction or sealing material needed; too porous to hold water.	Fair stability; good workability and compaction; erodible; poor resistance to piping.	Somewhat excessively drained; not needed.	Low available water capacity; rapid intake rate; frequent irrigation needed; erodible.	Sandy substratum; difficult to establish plants in channels; erodible.
Poor: low strength; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Good: high organic-matter content in thick surface layer.	Gentle slope; moderate permeability; seasonal high water table at a depth of 2 to 5 feet.	Adequate strength and stability; moderate to high shrink-swell potential.	Somewhat poorly drained; wetness because of seepage in places; interceptor tile needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent.	Features favorable; properly placed diversions help protect against overflow and siltation.
Good	Good to poor: many areas contain considerable fines.	Fair to a depth of 1 foot; coarse texture at a depth of 15 to 30 inches.	Sand and gravel at a depth of 15 to 30 inches; too porous to hold water.	Fair stability; good strength and compaction.	Somewhat excessively drained; not needed.	Very low available water capacity; rapid intake rate; rapid permeability in substratum limits effectiveness of irrigation.	Slopes generally short and irregular; sand and gravel at a depth of 15 to 30 inches.
Good	Good to poor: many areas contain considerable fines.	Fair to a depth of 1 foot; coarse texture at a depth of 15 to 30 inches.	Sand and gravel at a depth of 15 to 30 inches; too porous to hold water.	Fair stability; good strength and compaction.	Somewhat excessively drained; not needed.	Very low available water capacity; rapid intake rate; rapid permeability in substratum limits effectiveness of irrigation.	Slopes generally short and irregular; sand and gravel at a depth of 15 to 30 inches.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Everly:						
577B	Slight	Moderate: slopes of 2 to 5 percent.	Slight [1]	Slight	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained.
577C, 577C2	Slight	Severe: slopes of 5 to 9 percent.	Slight [1]	Slight	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained.
Fill land: 504	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: very poorly drained to poorly drained; poor bearing capacity.	Very severe: very poorly drained to poorly drained; seasonal high water table at a depth of 0 to 3 feet.	Very severe: very poorly drained to poorly drained; seasonal high water table.
Galva:						
310	Slight	Moderate: moderate permeability; high organic-matter content in surface layer.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Moderate: moderate to high shrink-swell potential.
310B	Slight	Moderate: moderate permeability; moderate or high organic-matter content in surface layer; slopes of 2 to 5 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Moderate: moderate to high shrink-swell potential.
310C2	Slight	Severe: slopes of 5 to 9 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Moderate: moderate to high shrink-swell potential.
T310	Slight: sand and gravel at a depth of 4 to 6 feet.	Moderate: moderate permeability; high organic-matter content in surface layer; sand and gravel at a depth of 4 to 6 feet.	Severe: sand and gravel at a depth of 4 to 6 feet; rapid permeability in sand and gravel; hazard of contaminating ground water.	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet; sand and gravel at a depth of 4 to 6 feet.	Moderate: moderate to high shrink-swell potential.
Gravel pits: 501	Not applicable	Severe: sand and gravel too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability; hazard of contaminating ground water.	Slight	Not applicable	Not applicable

properties of the soils—Continued

Suitability as source of— Road fill	Suitability as source of— Sand and gravel	Suitability as source of— Topsoil	Soil features affecting— Pond reservoir areas	Soil features affecting— Embankments, dikes, and levees	Soil features affecting— Drainage of cropland and pasture	Soil features affecting— Irrigation	Soil features affecting— Terraces and diversions
Good	Unsuited: no sand or gravel.	Good: moderate to high organic-matter content in surface layer.	Gentle slope; moderate permeability; slow rate of seepage where compacted; pockets of sand and gravel in places.	Good stability; good for impervious cores where compacted; stones and boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent; subject to rapid runoff; erodible.	Features favorable; stones and boulders in places; slopes of 2 to 5 percent.
Good	Unsuited: no sand or gravel.	Good: moderate to moderately low organic-matter content in surface layer.	Moderate slope; moderate permeability; slow rate of seepage where compacted; pockets of sand and gravel in places.	Good stability; stones and boulders in places; moderate shrink-swell potential.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 5 to 9 percent; subject to rapid runoff; erodible.	Features favorable; stones and boulders in places; slopes of 5 to 9 percent.
Very poor: poorly drained.	Unsuited: no sand or gravel.	Not applicable	Not applicable	Not applicable	Very poorly drained to poorly drained; seasonal high water table.	Not applicable	Not needed.
Fair: low strength; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Fair: fine texture.	Nearly level; moderate permeability.	Fair stability, workability, and compaction; medium compressibility.	Well drained; not needed.	High available water capacity; medium intake rate; nearly level.	Not needed.
Fair: low strength; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Fair: moderately fine texture.	Gentle slope; moderate permeability.	Fair stability, workability, and compaction; medium compressibility.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent.	Features favorable; slopes of 2 to 5 percent.
Fair: low strength; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Fair: moderately fine texture.	Moderate slope; moderate permeability.	Fair stability, workability, and compaction; medium compressibility.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 5 to 9 percent.	Features favorable; slopes of 5 to 9 percent.
Fair: low strength; moderate to high shrink-swell potential.	Good to poor: sand and gravel at a depth of 4 to 6 feet; many areas contain considerable fines.	Fair: moderately fine texture.	Nearly level; moderate permeability; sand and gravel at a depth of 4 to 6 feet.	Fair stability, workability, and compaction; medium compressibility.	Well drained; not needed.	High available water capacity; medium intake rate; nearly level.	Not needed.
Good	Good to poor: source exhausted in places.	Poor: no surface layer.	Porous sand and gravel.	Good stability; pervious where compacted.	Not applicable	Not applicable	Not applicable.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Harps: 95	Severe: seasonal high water table; adjacent to wet, depressional soils.	Severe: seasonal high water table; moderate to high organic-matter content in surface layer.	Severe: seasonal high water table; moderate permeability; adjacent to wet, depressional soils.	Severe: poorly drained.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; adjacent to depressional soils.	Severe: poorly drained; seasonal high water table; adjacent to depressional soils; moderate to high shrink-swell potential.
Lanyon: 606	Severe: subject to ponding; seasonal high water table; slow permeability.	Severe: subject to ponding; seasonal high water table; high organic-matter content in surface layer.	Severe: subject to ponding; seasonal high water table.	Severe: very poorly drained; subject to ponding; high shrink-swell potential.	Very severe: very poorly drained; seasonal high water table at a depth of 0 to 3 feet; subject to ponding; fine texture.	Very severe: very poorly drained; seasonal high water table; subject to ponding; high shrink-swell potential.
Lester:						
236F	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.[1]	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.
236G	Severe: slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.	Very severe: slopes of 25 to 40 percent.	Very severe: slopes of 25 to 40 percent.
Marcus: 92	Severe: seasonal high water table; moderately slow permeability.	Severe: high organic-matter content to a depth of about 2 feet; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet.	Severe: poorly drained; seasonal high water table; high shrink-swell potential.
Marsh: 354	Very severe: generally flooded.	Very severe: generally flooded.	Very severe: generally flooded.	Very severe: generally flooded; poor bearing capacity.	Very severe: generally flooded.	Very severe: generally flooded.
Millington: C458	Severe: subject to frequent flooding; seasonal high water table.	Severe: subject to frequent flooding; seasonal high water table; high organic-matter content.	Severe: subject to frequent flooding; seasonal high water table.	Severe: poorly drained; subject to frequent flooding; high organic-matter content.	Very severe: poorly drained; seasonal high water table at a depth of 0 to 2 feet; subject to frequent flooding.	Very severe: poorly drained; seasonal high water table at a depth of 0 to 3 feet; subject to frequent flooding.
Nicollet: 55, 251	Severe: seasonal high water table at a depth of 2 to 4 feet.	Severe: high organic-matter content in surface layer; seasonal high water table at a depth of 2 to 4 feet.	Severe: seasonal high water table at a depth of 2 to 4 feet.	Moderate: somewhat poorly drained.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.	Moderate: somewhat poorly drained; seasonal high water table; medium strength; moderate shrink-swell potential.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: poorly drained; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained; high content of calcium carbonate; low fertility; seasonal high water table.	Nearly level; moderate permeability; seasonal high water table.	Generally not used.	Poorly drained; seasonal high water table; moderate permeability; tile drains function well.	High available water capacity; medium intake rate; seasonal high water table.	Not needed.
Poor: very poorly drained; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: very poorly drained; fine texture; calcareous.	Nearly level; unsuitable for embankment ponds; suitable for dugout ponds in places; subject to ponding.	Poor workability and compaction; frequent high water table; subject to ponding.	Very poorly drained; surface drainage needed in places to remove water; tile drains function moderately well.	High available water capacity; medium to slow intake rate; frequent high water table; subject to ponding.	Not needed.
Good	Unsuited: no sand or gravel.	Poor: slopes 18 to 25 percent.	Moderate permeability; pockets of sand and gravel in places.	Good bearing capacity and shear strength; low compressibility; moderate shrink-swell potential.	Well drained: not needed.	Unsuited: slopes of 18 to 25 percent.	Unsuited: slopes of 18 to 25 percent.
Good	Unsuited: no sand or gravel.	Poor: slopes of 25 to 40 percent.	Moderate permeability; pockets of sand and gravel in places.	Good bearing capacity and shear strength; low compressibility; moderate shrink-swell potential.	Well drained: not needed.	Unsuited: slopes of 25 to 40 percent.	Unsuited: slopes of 25 to 40 percent.
Poor: poorly drained; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderately slow permeability; seasonal high water table.	Fair stability; poor compaction; high compressibility; slow permeability where compacted.	Poorly drained; moderately slow permeability; seasonal high water table; tile drains function well.	High available water capacity; medium to slow intake rate; seasonal high water table.	Not needed.
Poor: generally flooded.	Unsuited: no sand or gravel.	Unsuitable	Not applicable	Not applicable	Ponded areas	Not applicable	Not applicable.
Poor: poorly drained.	Unsuited: no sand or gravel.	Poor: poorly drained; seasonal high water table; subject to frequent flooding.	Nearly level; moderate permeability; seasonal high water table; subject to frequent flooding.	High organic-matter content to a depth of 3 feet or more; fair to poor stability; poor workability; poor for embankment foundations.	Poorly drained; seasonal high water table; moderate permeability; subject to frequent flooding.	Medium intake rate; high available water capacity; subject to frequent flooding.	Not needed.
Good	Unsuited: no sand or gravel.	Good: high organic-matter content in surface layer; medium texture.	Nearly level; moderate permeability.	Fair to good stability; high organic-matter content to a depth of 1½ feet; material below a depth of 1½ feet compacts to high density.	Somewhat poorly drained; benefits from tile drainage in places; tile drains function well; moderate permeability.	High available water capacity; medium intake rate; nearly level.	Nearly level; terraces generally not needed; features favorable; stones or boulders hinder construction in places.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Okoboji: 6	Severe: seasonal high water table; subject to ponding on surface; slow permeability.	Severe: seasonal high water table; high organic-matter content in surface layer.	Severe: seasonal high water table; subject to ponding on surface.	Severe: very poorly drained; subject to ponding on surface; high shrink-swell potential.	Very severe: very poorly drained; frequent high water table at a depth of 0 to 3 feet; subject to ponding.	Very severe: very poorly drained; seasonal high water table; subject to ponding; high shrink-swell potential.
Primghar: 91	Severe: seasonal high water table at a depth of 2 to 4 feet; moderate to moderately slow permeability.	Severe: moderate to moderately slow permeability; high organic-matter content in surface layer; seasonal high water table at a depth of 2 to 4 feet.	Severe: seasonal high water table at a depth of 2 to 4 feet.	Severe: high shrink-swell potential.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.	Moderate: somewhat poorly drained; seasonal high water table; medium strength; high shrink-swell potential.
91B	Severe: seasonal high water table at a depth of 2 to 4 feet; moderate to moderately slow permeability.	Severe: high organic-matter content in surface layer; seasonal high water table at a depth of 2 to 4 feet.	Severe: seasonal high water table at a depth of 2 to 4 feet.	Severe: high shrink-swell potential.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet.	Moderate: somewhat poorly drained; seasonal high water table; high shrink-swell potential.
Rolfe: 274	Severe: frequent high water table; subject to ponding; slow permeability.	Severe: subject to ponding; frequent high water table; high organic-matter content in surface layer.	Severe: subject to ponding; seasonal high water table.	Severe: very poorly drained; high shrink-swell potential.	Very severe: very poorly drained; seasonal high water table at a depth of 0 to 3 feet; subject to ponding.	Very severe: very poorly drained; seasonal high water table; subject to ponding; moderate to high shrink-swell potential.
Sac:						
77B	Slight: moderate permeability.[2]	Moderate: slopes of 2 to 5 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained; deep to water table.
77C2	Slight: moderate permeability.[2]	Severe: slopes of 5 to 9 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained; deep to water table.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: very poorly drained; high shrink-swell potential; low strength.	Unsuited: no sand or gravel.	Poor: very poorly drained.	Nearly level; moderately slow permeability; frequent high water table; subject to ponding.	High organic-matter content to a depth of 2 to 3 feet; fair to poor stability; high shrink-swell potential.	Very poorly drained; moderately slow permeability; tile drains function fairly well; open ditches or surface intakes needed; outlets need deep cuts in places.	Very poorly drained; generally not needed.	Not needed.
Poor: high shrink-swell potential; low strength.	Unsuited: no sand or gravel.	Fair to good: high organic-matter content in surface layer; moderately fine texture.	Nearly level; moderate to moderately slow permeability unless compacted; seasonal high water table at a depth of 2 to 4 feet.	Fair stability; high organic-matter content to a depth of 1½ feet.	Somewhat poorly drained; benefits from tile drainage in places; tile drains function well; moderate or moderately slow permeability.	High available water capacity; medium intake rate; nearly level.	Nearly level; terraces generally not needed.
Poor: high shrink-swell potential; low strength.	Unsuited: no sand or gravel.	Fair to good: high organic-matter content in surface layer; moderately fine texture.	Gentle slope; moderate to moderately slow permeability; seasonal high water table at a depth of 2 to 4 feet.	Fair stability; slow permeability where compacted; medium to high compressibility.	Somewhat poorly drained; benefits from tile drainage in places; tile drains function well.	High available water capacity; medium intake rate; gentle slope.	Gentle slope; features favorable.
Poor: very poorly drained; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: very poorly drained.	Nearly level; slow permeability; frequent high water table; subject to ponding.	Fair stability; slow permeability where compacted.	Very poorly drained; slow permeability; seasonal high water table; subject to ponding; tile drains function fairly well.	Medium to slow intake rate; high available water capacity; seasonal high water table; subject to ponding.	Not needed.
Fair in upper part. Good in underlying till.	Unsuited: no sand or gravel.	Fair to good: moderately fine texture.	Gentle slope; moderate permeability.	Poor stability to a depth of 2 to 3 feet; good stability below a depth of 3 feet; generally slow permeability where compacted; stones or boulders in places in underlying till.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent; subject to run-off and erosion.	Features favorable; slopes of 2 to 5 percent.
Fair in upper part. Good in underlying till.	Unsuited: no sand or gravel.	Fair to good: moderately fine texture.	Moderate slope; moderate permeability.	Poor stability to a depth of 2 to 3 feet; good stability below a depth of 3 feet; generally slow permeability where compacted; stones or boulders in places in underlying till.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 5 to 9 percent; subject to runoff and erosion.	Features favorable; slopes of 5 to 9 percent.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Sac—Continued						
78B	Moderate: moderate permeability.[3]	Moderate: slopes of 2 to 5 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained; deep to water table.
78C2	Moderate: moderate permeability.[3]	Severe: slopes of 5 to 9 percent.	Slight [1]	Moderate: moderate to high shrink-swell potential.	Slight: well drained; seasonal water table below a depth of 5 feet.	Slight: well drained; deep to water table.
Salida:						
73C	Moderate: very rapid permeability; hazard of contaminating ground water.	Severe: too porous to hold water; slopes of 5 to 9 percent.	Severe: very rapid permeability; hazard of contaminating ground water.	Slight	Moderate to severe: gravelly surface layer that has sand and gravel at a depth of 7 to 18 inches; excessively drained; water table below a depth of 5 feet.	Slight: excessively drained; deep to water table; low shrink-swell potential.
73D	Severe: slopes of 9 to 14 percent; very rapid permeability; hazard of contaminating ground water.	Severe: too porous to hold water; slopes of 9 to 14 percent.	Severe: very rapid permeability; severe hazard of contaminating ground water.	Slight	Moderate to severe: slopes of 9 to 14 percent; gravelly surface layer that has sand and gravel at a depth of 7 to 18 inches; excessively drained; water table below a depth of 5 feet.	Moderate: slopes of 9 to 14 percent.
Spicer: 32	Severe: seasonal high water table.	Severe: high organic-matter content to a depth of about 2 feet; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet.	Severe: poorly drained; seasonal high water table; high shrink-swell potential.
Spillville:						
485	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table; high organic-matter content in surface layer.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; subject to flooding; coarse-textured strata in places below a depth of 4 feet.	Severe: somewhat poorly drained; seasonal high water table; subject to flooding; fair bearing capacity and shear strength; coarse-textured strata in places below a depth of 4 feet.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair in upper part. Good in underlying till.	Unsuited: no sand or gravel.	Fair to good: moderately fine texture.	Gentle slope; moderate permeability.	Poor stability to a depth of 2 to 3 feet; good stability below a depth of 3 feet; generally slow permeability where compacted; stones or boulders in places in underlying till.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 2 to 5 percent; subject to runoff and erosion.	Features favorable; slopes of 2 to 5 percent; good management practices needed to establish plants in channels.
Fair in upper part. Good in underlying till.	Unsuited: no sand or gravel.	Fair to good to a depth of 1 foot. Fair below a depth of 1 foot: moderately fine texture.	Moderate slope; moderate permeability.	Poor stability to a depth of 2 to 3 feet; good stability below a depth of 3 feet; generally slow permeability where compacted; stones or boulders in places in underlying till.	Well drained; not needed.	High available water capacity; medium intake rate; slopes of 5 to 9 percent; subject to runoff and erosion.	Features favorable; slopes of 5 to 9 percent; good management practices needed to establish plants in channels.
Good	Good to poor: many areas contain considerable fines.	Poor: low organic-matter content; gravelly.	Too porous to hold water.	Fair stability; good shear strength; good compaction; somewhat pervious layers; stones or boulders in places.	Excessively drained; not needed.	Very low available water capacity; rapid intake rate; rapid permeability; short, uneven slopes; subject to runoff and erosion.	Shallow to sand and gravel; difficult to establish plants in channels.
Good	Good to poor	Poor: low organic-matter content; gravelly.	Too porous to hold water.	Fair stability; good shear strength; good compaction; somewhat pervious layers; stones or boulders in places.	Excessively drained; not needed.	Very low available water capacity; rapid intake rate; rapid permeability; short, uneven slopes; subject to runoff and erosion.	Shallow to sand and gravel; difficult to establish plants in channels.
Poor: poorly drained; high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderate permeability; seasonal high water table.	Fair stability; poor compaction; high compressibility; slow permeability where compacted.	Poorly drained; moderate permeability; seasonal high water table; tile drains function well.	High available water capacity; medium to slow intake rate; seasonal high water table.	Not needed.
Fair: somewhat poorly drained; moderate shrink-swell potential.	Unsuited: no sand or gravel.	Good: high organic-matter content in thick surface layer; medium texture.	Nearly level; moderate permeability; subject to flooding in places.	Fair stability; fair compaction below a depth of 2 to 3 feet; poor for embankment foundations.	Somewhat poorly drained; not needed in most places; subject to flooding in places.	High available water capacity; medium intake rate; subject to flooding in places.	Not needed.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Spillville—Continued						
485B	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table; high organic-matter content in surface layer.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding.	Severe: somewhat poorly drained; seasonal high water table at a depth of 2 to 4 feet; subject to flooding in places.	Moderate to severe: somewhat poorly drained; seasonal high water table; subject to flooding in places; fair bearing capacity and shear strength; coarse-textured strata in places below a depth of 4 feet.
Storden:						
62C	Slight	Severe: slopes of 5 to 9 percent.	Slight [1]	Slight	Slight: somewhat excessively drained; water table below a depth of 5 feet.	Slight: somewhat excessively drained; deep to water table.
62D	Severe: slopes of 9 to 14 percent.	Severe: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.	Moderate: slopes of 9 to 14 percent.
62E	Severe: slopes of 14 to 18 percent.	Severe: slopes of 14 to 18 percent.	Severe: slopes of 14 to 18 percent.[1]	Severe: slopes of 14 to 18 percent.	Severe: slopes of 14 to 18 percent.	Severe: slopes of 14 to 18 percent.

properties of the soils—Continued

	Suitability as source of—			Soil features affecting—				
	Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
	Fair: somewhat poorly drained; moderate shrink-swell potential.	Unsuited: no sand or gravel.	Good: high organic-matter content in thick surface layer; medium texture.	Gentle slope; moderate permeability; subject to flooding in places.	Fair stability; fair compaction below a depth of 2 to 3 feet; poor for embankment foundations.	Somewhat poorly drained; not needed in most places; subject to flooding in places.	High available water capacity; medium intake rate; subject to flooding in places.	Features favorable; properly placed diversions help protect against overflow and siltation.
	Good	Unsuited: no sand or gravel.	Fair: low organic-matter content; calcareous.	Slopes of 5 to 9 percent; moderate permeability; pockets of sand or gravel in places.	Good stability; good compaction; slow permeability where compacted; stones or boulders in places.	Somewhat excessively drained; not needed.	High available water capacity; medium intake rate; limited by low fertility; slopes of 5 to 9 percent.	Short, irregular slopes in many places; good management practices needed to establish plants in channels; stones or boulders in places; slopes of 5 to 9 percent.
	Good	Unsuited: no sand or gravel.	Fair: slopes of 9 to 14 percent; low organic-matter content; calcareous.	Slopes of 9 to 14 percent; moderate permeability; pockets of sand or gravel in places.	Good stability; good compaction; slow permeability where compacted; stones or boulders in places.	Well drained; not needed.	High available water capacity; medium intake rate; limited by low fertility; strong slopes of 9 to 14 percent.	Short, irregular slopes in many places; good management practices needed to establish plants in channels; stones or boulders in places; strong slopes of 9 to 14 percent.
	Good	Unsuited: no sand or gravel.	Poor: slopes of 14 to 18 percent; low organic-matter content; calcareous.	Moderately steep slope; moderate permeability; pockets of sand or gravel in places.	Good stability; good compaction; slow permeability where compacted; stones or boulders in places.	Well drained; not needed.	High available water capacity; medium intake rate; limited by low fertility; moderately steep slopes of 14 to 18 percent.	Good management practices needed to establish plants in channels; stones or boulders in places; moderately steep slopes of 14 to 18 percent.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Storden—Continued						
62F	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.[1]	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.	Severe: slopes of 18 to 25 percent.
62G	Severe: slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.	Severe: slopes of 25 to 40 percent.[1]	Severe: slopes of 25 to 40 percent.	Very severe: slopes of 25 to 40 percent.	Very severe: slopes of 25 to 40 percent.
Talcot:						
559	Severe: seasonal high water table; rapid permeability in substratum; hazard of contaminating ground water.	Severe: substratum too porous to hold water; hazard of contaminating ground water; seasonal high water table.	Severe: seasonal high water table; rapid permeability in substratum; hazard of contaminating ground water.	Severe: very poorly drained.	Severe: very poorly drained; seasonal high water table at a depth of 1 to 3 feet; sand and gravel at a depth of 32 to 40 inches.	Severe: very poorly drained; seasonal high water table; sand and gravel at a depth of 32 to 40 inches; moderate to high shrink-swell potential.
558	Severe: seasonal high water table; rapid permeability in substratum; hazard of contaminating ground water.	Severe: substratum too porous to hold water; hazard of contaminating ground water; seasonal high water table.	Severe: seasonal high water table; rapid permeability in substratum; hazard of contaminating ground water.	Severe: very poorly drained.	Severe: very poorly drained; seasonal high water table at a depth of 1 to 3 feet; sand and gravel at a depth of 24 to 32 inches.	Severe: very poorly drained; seasonal high water table; sand and gravel at a depth of 24 to 32 inches; moderate to high shrink-swell potential.
Terril: 27C	Slight	Moderate: slopes of 4 to 9 percent; high organic-matter content; moderate permeability.	Slight [1]	Moderate: moderate shrink-swell potential; high organic-matter content to a depth of 2 to 3 feet; subject to runoff from higher areas.	Moderate: moderately well drained; water table below a depth of 5 feet; subject to runoff from higher areas.	Moderate: subject to runoff from higher areas; moderate shrink-swell potential.
Wacousta: 506	Severe: frequent high water table; subject to ponding on surface; moderate to moderately slow permeability.	Severe: high organic-matter content in surface layer; frequent high water table.	Severe: seasonal high water table; subject to ponding on surface.	Severe: very poorly drained; moderate to high shrink-swell potential.	Very severe: very poorly drained; frequent high water table at a depth of 0 to 3 feet; subject to ponding.	Very severe: very poorly drained; frequent high water table; subject to ponding; fair to poor bearing capacity.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Good	Unsuited: no sand or gravel.	Poor: slopes of 18 to 25 percent; low organic-matter content; calcareous.	Steep slope; moderate permeability; pockets of sand or gravel in places.	Good stability; good compaction; slow permeability where compacted; stones or boulders in places.	Well drained; not needed.	Unsuited: slopes of 18 to 25 percent.	Unsuited: slopes of 18 to 25 percent.
Good	Unsuited: no sand or gravel.	Poor: slopes of 25 to 40 percent; low organic-matter content; calcareous.	Very steep; moderate permeability; pockets of sand or gravel in places.	Good stability; good compaction; slow permeability where compacted; stones or boulders in places.	Well drained; not needed.	Unsuited: slopes of 25 to 40 percent.	Unsuited: slopes of 25 to 40 percent.
Poor: very poorly drained.	Fair to poor: many areas contain considerable fines; seasonal high water table.	Poor: very poorly drained; seasonal high water table.	Porous sand and gravel substratum; nearly level.	High organic-matter content to a depth of about 2 feet; substratum stable but pervious.	Very poorly drained; seasonal high water table; tile drains function well, but underlying sand and gravel hinder installation in places.	Moderate to high available water capacity; medium intake rate; nearly level.	Not needed.
Poor: very poorly drained.	Fair to poor: many areas contain considerable fines; seasonal high water table.	Poor: very poorly drained; seasonal high water table.	Porous sand and gravel substratum; nearly level.	High organic-matter content to a depth of about 2 feet; substratum stable but pervious.	Very poorly drained; seasonal high water table; tile drains function well, but underlying sand and gravel hinder installation in places.	Low to moderate available water capacity; medium intake rate; nearly level; rapid permeability in substratum limits effective irrigation to a depth of 2 to 3 feet.	Not needed.
Fair: medium strength; moderate shrink-swell potential.	Unsuited: no sand or gravel.	Good: high organic-matter content to a depth of 2 to 3 feet; medium texture.	Moderate permeability; slopes of 4 to 9 percent.	High organic-matter content to a depth of 2 feet or more; fair stability; fair to poor workability and compaction; medium compressibility.	Moderately well drained; not needed.	High available water capacity; medium intake rate; subject to rapid runoff, erosion, and gullying; slopes of 4 to 9 percent.	Features favorable; properly placed diversions help protect against overflow and siltation.
Poor: very poorly drained; subject to ponding.	Unsuited: no sand or gravel.	Poor: very poorly drained.	Nearly level; moderate to moderately slow permeability; high organic-matter content in surface layer; subject to ponding.	Poor workability and compaction; high organic-matter content in surface layer; seasonal high water table; subject to ponding.	Very poorly drained; moderate to moderately slow permeability; tile drains function well; open intake or surface drains needed; deep cuts needed in placed for outlets.	High available water capacity; medium intake rate; seasonal high water table; subject to ponding.	Not needed.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Wadena: 308B	Slight: rapid permeability in substratum; hazard of contaminating ground water.	Severe: sand and gravel in substratum too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability in substratum; hazard of contaminating ground water.	Slight	Slight to moderate: well drained; water table below a depth of 5 feet; sand and gravel at a depth of 32 to 40 inches.	Slight: well drained; deep to water table; sand and gravel at a depth of 32 to 40 inches.
108	Slight: rapid permeability in substratum; hazard of contaminating ground water.	Severe: sand and gravel in substratum too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability in substratum; hazard of contaminating ground water.	Slight	Slight to severe: well drained; water table below a depth of 5 feet; sand and gravel at a depth of 24 to 32 inches.	Slight: well drained; deep to water table; sand and gravel at a depth of 24 to 32 inches.
108B	Slight: rapid permeability in substratum; hazard of contaminating ground water.	Severe: sand and gravel in substratum too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability in substratum; hazard of contaminating ground water.	Slight	Slight to severe: well drained; water table below a depth of 5 feet; sand and gravel at a depth of 24 to 32 inches.	Slight: well drained; deep to water table; sand and gravel at a depth of 24 to 32 inches.
108C2	Moderate: rapid permeability in substratum; hazard of contaminating ground water.	Severe: slopes of 5 to 9 percent; sand and gravel in substratum too porous to hold water; hazard of contaminating ground water.	Severe: rapid permeability in substratum; hazard of contaminating ground water.	Slight	Slight to severe: well drained; water table below a depth of 5 feet; sand and gravel at a depth of 24 to 32 inches.	Slight: well drained; deep to water table; sand and gravel at a depth of 24 to 32 inches.
Waldorf: 390	Severe: moderately slow permeability; seasonal high water table.	Severe: high organic-matter content in surface layer; seasonal high water table.	Severe: seasonal high water table.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet; fine texture.	Severe: poorly drained; seasonal high water table; high shrink-swell potential.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair to good above a depth of about 3 feet. Good below a depth of about 3 feet.	Good to poor: many areas contain considerable fines.	Good: moderate organic-matter content in surface layer; medium texture.	Gentle slope; porous sand and gravel substratum.	Good stability; substratum pervious where compacted.	Well drained; not needed.	Moderate to high available water capacity; medium intake rate; slopes of 1 to 5 percent.	Slopes generally short and irregular; sand and gravel below a depth of about 3 feet.
Fair to good above a depth of about 2 feet. Good below a depth of about 2 feet.	Good to poor: many areas contain considerable fines.	Good: high to moderate organic-matter content in surface layer; medium texture.	Nearly level; porous sand and gravel substratum.	Good stability; substratum pervious where compacted.	Well drained; not needed.	Low to moderate available water capacity; medium intake rate; rapid permeability in substratum limits effectiveness of irrigation to a depth of only 2 to 3 feet; nearly level.	Not needed.
Fair to good to a depth of about 2 feet. Good below a depth of about 2 feet.	Good to poor: many areas contain considerable fines.	Good: moderate organic-matter content in surface layer; medium texture.	Gentle slope; porous sand and gravel substratum.	Good stability; substratum pervious where compacted.	Well drained; not needed.	Low to moderate available water capacity; medium intake rate; rapid permeability in substratum limits effectiveness of irrigation to a depth of only 2 to 3 feet; gentle slopes of 2 to 5 percent.	Slopes generally short and irregular; sand and gravel below a depth of 2 to 2½ feet; slopes of 2 to 5 percent.
Fair to good to a depth of about 2 feet. Good below a depth of about 2 feet.	Good to poor: many areas contain considerable fines.	Good: modererate to moderately low organic-matter content in surface layer; medium texture.	Porous sand and gravel substratum; slopes of 5 to 9 percent.	Good stability; substratum pervious where compacted.	Well drained; not needed.	Low to moderate available water capacity; medium intake rate; rapid permeability in substratum limits effectiveness of irrigation to a depth of only 2 to 3 feet; slopes of 5 to 9 percent.	Slopes generally short and irregular; sand and gravel below a depth of 2 to 2½ feet; slopes of 5 to 9 percent.
Poor: poorly drained; high shrink-swell potential; low strength.	Unsuited: no sand or gravel.	Poor: poorly drained; fine texture.	Nearly level; moderately slow permeability; seasonal high water table.	Fair stability; poor compaction; high compressibility; high shrink-swell potential.	Poorly drained; moderately slow permeability; seasonal high water table; tile drains do not function well; surface drains beneficial in places.	High available water capacity; generally slow intake rate.	Not needed.

TABLE 5.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for–					
	Septic-tank absorption fields	Sewage lagoons	Sanitary landfill	Local roads and streets	Shallow excavations	Dwellings without basements
Webster: 107	Severe: seasonal high water table; moderately slow to moderate permeability.	Severe: seasonal high water table; high organic-matter content in surface layer.	Severe: seasonal high water table.	Severe: poorly drained; moderate shrink-swell potential.	Severe: poorly drained; seasonal high water table at a depth of 1 to 3 feet.	Severe: poorly drained; seasonal high water table.

[1] Water table of these soils is at a depth of more than 5 feet.

[2] Permeability estimated to be 1.0–2.0 inches per hour (in the upper part of the moderate permeability class).

areas the density of the loess is fairly low in places, and the moisture content is high. The high moisture content causes instability of embankments where moisture is not carefully controlled at the time of compaction.

The soils that formed in loamy till, such as the Clarion, Nicollet, and Storden, range from loam to clay loam and are classified A–4 or A–6 and CL. Where these soils are in or adjacent to road grades, the material generally is placed in the upper part of the subgrade in areas that are unstable. Pockets and lenses of sand generally are interspersed throughout the till and generally are water bearing.

Where the road grade is only a few feet above the till the surface layer is silty, frost heaving is likely to occur unless the till is drained or the soil above the till is replaced with granular backfill or clayey till. Poorly drained soils that formed in glacial till and glacial sediment, such as these of the Webster series, are classified A–7 and OH to CL. In places these soils have high moisture content and low density. Because good subgrade bearing capacity cannot be obtained from material in these soils, this material should be placed at least 3 feet below the top of the subgrade. Also, material from all other soils in the county that are highly organic and that have a surface layer of low density should be placed at that depth.

Soils that formed in loam and clay loam on glacial outwash benches are fine textured and are classified A–4 or A–6 and ML or CL. These soils, such as the ones of the Wadena and Cylinder series, are underlain by stratified sand and gravel. The sand and gravel are classified A–1 or A–2 and SP-SM. The gently sloping Wadena soils generally have a thin surface layer, but sand and gravel in the underlying layers can be used as borrow material and placed in the upper part of the subgrade. Frost heaving may result, however, unless the level areas are properly drained.

Soils on bottom lands in the county formed in alluvium. The Colo soils formed in alluvium and are classified A–7 and OL or CH. These soils are silty clay loam and have a thick, organic surface layer that may consolidate erratically under embankment loads. The Colo soils have high moisture content and low density in places.

The clayey Waldorf and Collinwood soils formed in lacustrine deposits and are classified A–6 or A–7 and CL or CH. These soils are on uplands and glacial outwash benches. They generally are in small areas and, in most places they can be bypassed in highway construction. If these soils must be crossed by road grade, excavation to a firm subsoil may be needed. If this is the case, backfilling with granular material may be desirable.

Formation and Classification of the Soils

The factors of soil formation are listed and discussed as they relate to the formation of soils in Bunea Vista County in the first part of this section, the formation of horizons and the processes of their formation are discussed in the second part. The system of soil classification currently used is discussed in the third and last part, and each soil series of Buena Vista County is classified according to that system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at a given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil that has a distinctive profile. Generally it takes a long time for distinct horizons to develop, but the time required to develop noticeable horizonal differentiation may be either long or short in terms of the developmental history of soils.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect on any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

properties of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: poorly drained; moderate to high shrink-swell potential.	Unsuited: no sand or gravel.	Poor: poorly drained.	Nearly level; moderately slow permeability; seasonal high water table.	Fair stability and compaction below a depth of 1½ to 2 feet; slow permeability where compacted.	Poorly drained; seasonal high water table; moderate to moderately slow permeability; tile drains function well if outlets are adequate.	High available water capacity; medium intake rate; nearly level.	Not needed.

[3] Permeability estimated to be 0.6–1.0 inch per hour (in the lower part of the moderate permeability class).

Parent material

The soils of Buena Vista County formed in glacial till, glacial outwash, loess, alluvium, eolian sand, and lacustrine sediment. The bedrock underlying these materials is so deep that it has had no influence on the formation of the soils.

The soils of the county have been affected by three stages of glaciation—the Nebraskan, the Kansan, and the Wisconsin. In this county the till from the Nebraskan and Kansan stages is deeply buried and is not visible, but there is some speculation that the Kansan till may be present under the thin, loess-mantled soils in the southwestern part of the county in soil association 3.

The eastern and central part of the county was covered by the Des Moines lobe of the Wisconsin glaciation (*3*, *5*). It was formerly believed that the Des Moines lobe occured in two substages, the Cary and the Mankato (*3*, *5*, *7*). According to this view, the central part of the county between Brooke Creek and the Raccoon River lies in the Cary substage area, but the area east of the Raccoon River is covered by Mankato substage material, which is most recent. In more recent investigations, however, the evidence indicates that most, if not all, of the Des Moines lobe is of Cary age (*4*, *7*). Radiocarbon dating has determined that the Cary substage occurred between about 14,000 and 13,000 years ago (*7*). The evidence for the geologic youth of the Cary substage is the lack of deep weathering, the unleached calcareous till at a shallow depth, and the poorly developed surface drainage and many closed depressions.

In most of the western part of the county the Tazewell substage of the Wisconsin glaciation deposited surface drift. Radiocarbon dates of wood obtained at the base of the till near Cherokee indicate that this substage occurred about 20,000 years ago (*5*, *15*). Loess that is 30 to 60 inches thick, except on steep, eroded slopes, mantles much of the area. This loess was deposited by wind over the Tazewell drift 14,000 to 20,000 years ago (*5*).

Glacial till is exposed in the central and eastern part of the county and in the sloping areas of the western part where the loess mantle has been removed by erosion. The major soils that formed in the glacial till are the Clarion and Storden soils. The Webster, Nicollet, Canisteo, Blue Earth, Okoboji, Rolfe, and Wacousta soils formed in reworked glacial till and local alluvium, or partly in this material and partly in till.

Glacial outwash, or material deposited by melt water from glaciers, makes up extensive deposits of sand and gravel on benches along the Little Sioux and Raccoon Rivers. Similar deposits that are less extensive and shallow occur along other streams and near moraines in the central part of the county. The Biscay, Cylinder, Talcot, and Wadena soils formed in glacial outwash and overlie sand and gravel.

Loess consists mainly of particles of silt and clay deposited by wind. Loess covers extensive areas, mainly in the western and south-central parts of the county. The soils that formed in loess are the Galva, Marcus, and Primghar soils. Sac soils formed partly in loess are partly in the underlying glacial till.

Alluvium consists of sediment deposited by streams. The Colo, Calco, Millington, and Spillville soils formed in alluvial sediment. The Ely and Terril soils formed in local alluvium that recently was washed from adjacent soils.

Eolian sand consists of sand that is assumed to have been deposited by wind. The fine sand was probably blown from the river flood plains or from benches. The Dickinson soils formed in this sandy material, which most likely was deposited by water, although there is some indication that in some parts of the county much of this material was deposited or reworked by wind.

Lacustrine sediment is in deposits of variable thickness, often 4 to 5 feet thick or more. The Collinwood and Waldorf soils formed in water-laid lacustrine sediment.

Climate

Climate influences the formation of soils in many ways. Rainfall affects the amount of leaching in soils and influences the kind and amount of vegetation that grows on soils. Temperature affects the growth of plants, the activity of microorganisms, and the rapidity of chemical reactions. The major differences among soils within the county, however, are attributable to factors other than climate.

Available information indicates that the soils in Buena Vista County have been forming in a midcontinental, subhumid climate for the last 5,000 years. Between 5,000 and 16,000 years ago the climate was conducive to forest vegetation (*7*). Lane assumes that the successions of vegetation in post-Mankato time, from about 11,000 years ago to the present, have been caused by changes in climate (*2*). From these successions of vegetation he infers that there have

been three shifts in climate. These shifts were: a warming condition that produced a change from coniferous to deciduous trees, and gradual desiccation prior to the appearance of grasses, and continued drying that produced a climate more favorable to grasses. The recent work on climate by Walker and Brush (*13*) corroborates the findings of Lane. Some soils of Buena Vista County, however, do not have characteristics that indicate that they were ever forested.

Plant and animal life

Plants and animals have greatly influenced the formation of soils in Buena Vista County. Micro-organisms have helped in the decay of organic matter. The native vegetation of Buena Vista County at the time of settlement was mainly tall prairie grasses, but a few areas, mainly along the Little Sioux River, were in trees. Ruhe and Scholtes (*7*) report that for the last 5,000 years the environment in Iowa has been conducive to prairie plants. Between 5,000 and 16,000 years ago, however, the cooler, more moist climate was more favorable to trees. The effect of this period of forest vegetation is not reflected in the formation of the Clarion, Galva, Nicollet, Primghar, Sac, or other dark-colored soils that formed more recently under prairie vegetation.

Most of the soils of Buena Vista County formed under prairie grasses. The formation of Lester soils, however, was influenced by trees at least part of the time. It may be that they began forming under grasses, and the grasses were later encroached upon by trees. The vegetation in potholes and other depressions was sedges, cattails, rushes, and similar plants.

Under similar conditions, soils that formed under grass are darker and less acid and have a thicker surface layer than soils that formed under trees. Soils that formed under vegetation consisting of mixed grass and trees have properties that are intermediate between those of soils that formed under grass and those of soils that formed under trees.

Relief

Relief is important in soil formation mainly because it affects drainage and erosion. Soil erosion generally increases as steepness increases. Less water soaks into steeper soils, and leaching of carbonates and movement of clay from the surface soil to the subsoil are both less in these soils. In the nearly level or depressed areas, soils such as those of the Webster series are wet and frequently have a gray or mottled subsoil that results from poor aeration and restricted drainage.

The relief of the eastern and central part of the county is geologically immature, as shown by the large number of potholes and other depressions and by the absence of well-developed upland streams. The western part of the county is somewhat more dissected in some areas, but relief is also fairly immature. Areas adjacent to the major streams are dissected, but streams have not extended their channels much at the heads. Most of Buena Vista County is nearly level to rolling. Many of the soils in the nearly level areas are poorly drained. Most of the soils that are gently sloping or moderately sloping, such as Clarion or Sac soils, are well drained.

The thickness and color of the A horizon and the thickness of the solum are also related to slope. Generally the Storden soils have steep slopes, the Clarion soils have intermediate slopes, and the Nicollet soils are nearly level. The thickness of the A horizon increases and the color becomes darker in these soils as the slope decreases. In like manner, the thickness of the solum increases from the thinner Storden soils to the thicker Clarion and Nicollet soils.

Time

The radiocarbon technique for determining the age of carbonaceous material found in loess and glacial till has made it possible to determine the approximate ages of soils and of Pleistocene geologic deposits in Iowa. For example, the age of the Cary substage of the Wisconsin glaciation, according to studies by Ruhe and Scholtes (*4, 5, 7*), has been determined to be between about 14,000 and 13,000 years. Soils that formed in Cary till include the Clarion, Nicollet, and Webster soils.

The Tazewell loess, in which most soils on uplands in the western part of the county formed, was deposited prior to the approximate period of 15,000 to 17,000 years ago (*6*). Soils that formed in Tazewell loess include Galva, Marcus, Primghar, and Sac.

The soils that formed in glacial outwash, such as the Wadena and Talcot soils, are less than about 13,000 years old. Soils that formed in alluvium range in age from recently deposited material to material less than 13,000 years old. Colo, Calco, Spillville, and Millington are examples of soils that formed in alluvium.

Soils such as Clarion, Storden, and other sloping soils are subject to geological erosion, which continues to expose deeper material. These soils therefore range in age from the time when their parent material was deposited to recent time.

Formation of horizons

In Buena Vista County morphology is expressed by faint soil horizons in most soils. The Clarion, Marcus, Sac, Storden, and Webster soils have faint horizons; the Rolfe soils, prominent horizons; and the Lester soils, intermediate horizons. In some soils, such as those of the Biscay, Cylinder, Talcot, and Wadena series, there is a marked difference between the texture of the solum and the underlying IIC horizon.

Horizon differentiation in soils is the result of one or more of the following processes: accumulation of organic matter, leaching of calcium carbonate and other bases, formation and translocation of silicate clay minerals, reduction and transfer of iron, and accumulation of calcium carbonates. In most of the soils of the county two or more of these processes have been active in the formation of horizons.

Most soils in Buena Vista County have some accumulation of organic matter in the upper part that forms an A1 horizon. Some of the soils that have a high content of organic matter are the Blue Earth, Colo, Okoboji, Wacousta, and Webster soils. The Salida and Storden soils have a moderately low to very low content of organic matter and have a faint, thin A1 horizon. Many soils in the county have a moderate content of organic matter.

Leaching of calcium carbonates and other bases has occurred in many soils in the county. It generally occurs before and during the translocation of silicate clay minerals. Many of the soils in Buena Vista County, including the Clarion, Nicollet, and Webster soils, have been leached of calcium carbonate to a shallow depth, but little clay has been moved downward in their profiles. The Lester and Rolfe soils generally are more strongly leached throughout their profiles and have a distinct accumulation of silicate clay in the B horizon.

The translocation of silicate clay minerals has contributed to the prominent horizonation in the Lester soils. The B horizon in these soils has more clay than the A horizon and often has dark-colored clay coatings on the ped surfaces and along root channels. The elluviated A2 horizon has platy structure, has less clay, and generally is lighter colored than the B horizon. The process of leaching of bases and translocation of clay in these soils have been more important in horizon differentiation than the accumulation of organic matter.

Horizonation is faintly expressed in the Harps and Canisteo soils. Carbonates have accumulated in the surface layer and subsoil. The calcium carbonate equivalent of the Harps soils is 10 to 40 percent.

Gleying, or the process of reduction and transfer of iron (*8*), is evident in the poorly drained and very poorly drained soils. The Afton, Biscay, Blue Earth, Calco, Canisteo, Colo, Harps, Marcus, Okoboji, Spicer, Wacousta, and Webster soils have a gleyed Bg horizon. This horizon is gray, which indicates the reduction and loss of iron. Some soils have reddish-brown concretions of iron.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First through classification, and then through the use of soil maps, we can apply our knowledge of soils to specific fields and to other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study. Readers interested in developments of the current system, therefore, should search for the latest literature available (*11*). In table 6, the soil series of Buena Vista County are placed in three categories of the current system.

The current system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. Most of the classes of the current system are briefly defined in the following paragraphs:

ORDER.—Ten soil orders are recognized: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. The three soil orders in Buena Vista County, as indicated in table 6, are Entisols, Mollisols, and Alfisols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Mollisols formed under grass and have a thick, dark-colored surface horizon that contains colloids dominated by bivalent cations. The soil material in these soils has not been mixed by shrinking and swelling.

Alfisols are mineral soils that contain horizons of clay accumulation. Unlike the Millisols, they lack a thick, dark-colored surface layer that contains colloids dominated by bivalent cations, but the base status of the lower horizons is not extremely low.

SUBORDER.—Each order is subdivided into suborders, mainly on the basis of the characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Udolls (ud meaning humid, and oll for Mollisol).

GREAT GROUP.—Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major horizons and soil features. The horizons used to make separations are those in which clay, iron, or humus has accumulated or those that contain a pan that interferes with the growth of roots or the movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 6, because it is the last word in the name of the subgroup. The names of the great groups have three syllables and are made by adding a prefix to the name of the suborder. An example is Hapludoll (hapl meaning simple, ud for humid, and oll for Mollisol).

SUBGROUP.—Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and other groups, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups are also made in those instances where soil properties intergrade outside the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Hapludoll.

FAMILY.—Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. The family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names of texture, mineralogy, etc., that are used as family differentiae. An example is fine-loamy, mixed, mesic family of Typic Hapludolls.

SERIES.—The series is a group of soils that formed in a particular kind of parent material and have genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

TABLE 6.—*Soil series classified according to the current system of classification*

Series	Family	Subgroup	Order
Afton	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Haplaquolls	Mollisols.
Blue Earth	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Calco	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Canisteo	Fine-loamy, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Clarion	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Collinwood	Fine, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Aquic Hapludolls	Mollisols.
Dickinson	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Ely	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Estherville	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Everly	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Galva	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Harps	Fine-loamy, mixed, mesic	Typic Calciaquolls	Mollisols.
Lanyon [1]	Fine, montmorillonitic, mesic	Typic Haplaquolls	Mollisols.
Lester	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Marcus	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Millington [2]	Fine-loamy, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Nicollet	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols.
Okoboji	Fine, montmorillonitic, mesic	Cumulic Haplaquolls	Mollisols.
Primghar	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Rolfe [3]	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Sac	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Spicer	Fine-silty, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Storden	Fine-loamy, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Wacousta	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols.
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Waldorf	Fine, montmorillonitic, mesic	Typic Haplaquolls	Mollisols.
Webster	Fine-loamy, mixed, mesic	Typic Haplaquolls	Mollisols.

[1] The Lanyon soils in this county are taxadjuncts to the series because they have free carbonates at a shallower depth than defined in the range for the series.
[2] The Millington soils in this county are taxadjuncts to the series because they have more stratification in the upper part of the solum, have an apparent buried soil in the lower part of the solum, and have colors with moist value of 3 or less to a greater depth than defined in the range for the series.
[3] The Rolfe soils in this county are taxadjuncts to the series, because mollic colors are not thick enough to qualify as mollic epipedons.

New soil series must be established, and concepts of some established series, especially older ones that have been little used in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept, at Federal, State, and regional levels of responsibility for classification, results in a judgment that the new series should be established. All of the soil series described in this survey have been established at an earlier time. They are given the name of a geographic location near the place where the series was first observed and mapped. The Clarion series is an example.

General Nature of the County

This section is particularly for those who are not familiar with Buena Vista County. It discusses briefly the history, relief, drainage, and climate of the county and gives some farming statistics.

History

When Buena Vista County was surveyed in 1855, native prairie covered more than 97 percent of the county. The first permanent settler was Abner Bell (*14*). His home was near Sioux Rapids, and the first settlement was made along the Little Sioux River. Sioux Rapids was the county seat when the county was organized in 1858, but Storm Lake became the county seat in 1878. Settlers moved in from eastern Iowa, Indiana, Ohio, and other states farther east, as well as from Denmark, Germany, Norway, and Sweden. By 1915 the population of the county was 17,212. By 1917 the rural population was very evenly distributed throughout the county.

Relief and Drainage

The glacial till plains and the loess-mantled plain on uplands are the two major physiographic areas of the county.

The glacial till plains are in the eastern and central part of the county. They are characterized by short, irregular, undulating slopes and nearly level areas that have many landlocked depressions called "potholes."

The loess-mantled plain is in the western part of the county. It is moderately dissected by drainageways and small streams. The loess-mantled plain generally has long, nearly level and gentle slopes, but shorter, moderate slopes are adjacent to the larger drainageways and stream valleys.

The steepest areas in the county are the breaks between the uplands and bottom lands along the Little Sioux River and Brooke Creek.

More than 60 percent of the county is in the Raccoon River watershed. Raccoon River originates in Poland Township and flows through, Lee, Lincoln, Grant, and Providence Townships. This watershed includes the Storm

Lake watershed, which empties into Outlet Creek. Outlet Creek, in turn, empties into Raccoon River.

The Little Sioux River, which flows through the northern part of Lee, Barnes, and Brooke Townships drains more than 90,000 acres of Buena Vista County, mainly through the Brooke Creek watershed. Brooke Creek flows north to north-northwest through Washington Township, the southwestern corner of Scott Township, and Elk and Brooke Townships.

The Maple River in Cherokee County drains more than 30,000 acres of Buena Vista County through the Little Maple River in Maple Valley and Nokomis Townships, through Maple Creek in Brooke and Elk Townships, and through an unnamed creek in the northwestern part of Nokomis Township.

The Boyer River, through the Boyer River in Hayes and Maple Valley Townships and Boyer Creek in Hayes Township, drains more than 13,000 acres.

The Raccoon River watershed is part of the Mississippi River watershed area, and the Little Sioux, Maple, and Boyer River watersheds are part of the Missouri River watershed area.

Climate [4]

Tables 7 and 8 present temperature, precipitation, and freeze data for Buena Vista County. Although these data were recorded at the weather station at Storm Lake, they generally are representative of most of the county.

On clear, calm nights, river valleys and areas that are relatively low compared to the surrounding areas may have minimum temperatures that are several degrees lower than those of upland or urban areas. Maximum temperatures do not vary so much, but extreme temperatures may be slightly less at Storm Lake. In an average year the number of days that have maximum temperatures of 90° or higher ranges from 16 days at Storm Lake to 26 days at Sioux Rapids. These temperatures are too high for optimum crop production, because water demand is excessive on those days.

Annual precipitation ranges from about 28.5 inches in the southeast to slightly less than 28 inches in the northwest. About 75 percent of the annual precipitation falls as showers during the warm season of April through September. In the years 1951 to 1960 at Storm Lake, there was an average of 18 days in which rainfall was 0.5 inch or more and an average of 50 days in which it was 0.10 inch or more.

Heavy rains are important in determining the erosion potential. Most of the heavy showers fall during the warm half of the year, with the months of May, June, and August averaging 3 days each. The amount of precipitation in individual showers varies in different parts of the county, but over a long period the total average rainfall in showers is about the same throughout. June averages out as the wettest month of the year, and periods of drought in the summer are most likely to occur in July. The probability of receiving an inch or more of rainfall in a 1-week period is about 4 years in 10 in June and slightly less than 3 years in 10 in July and August. Well-developed crops use more than an inch of water a week during the summer.

The amount of moisture in the soil is an important factor in growth and survival of crops. A 5-inch reserve of available soil moisture is considered a critically low level in spring. In the southeastern part of the county there is about a 25-percent probability of having less than 5 inches of plant-available water present in the upper 5 feet of soil on April 15, but in the northwestern part this probability increases to 35 percent. The probability of having more than 9 inches available at this time is less than 20 percent.

Farming

Most of Buena Vista County is farmland. These farms are mainly used for corn, soybeans, oats, and hay, but they are also used for pasture. The principal livestock enterprises are raising hogs and feeding beef cattle. The acreage of each crop grown in 1971 and the number of each kind of livestock raised or fed in 1971 are listed below. The type and size of farms in the county in 1971 are also given. All of the data are from the Iowa Annual Farm Census (*12*).

Corn, soybeans, oats, and hay are the principal crops grown in Buena Vista County. Corn is grown on the largest acreage. Grain, especially corn and soybeans, is the main cash crop, but much of the corn and small grain are fed to hogs, cattle, and sheep on the farms.

The number of acres used for the principal crops and for pasture in 1971 are as follows:

Crops	*Acres*
Corn for all purposes	157,701
Oats for grain	12,546
Soybeans for beans	86,927
Sorghum	483
All hay	9,230
Pasture	28,385

Raising livestock, especially hogs, and fattening beef cattle are the main enterprises on many farms in the county. Farmers derive much of their income from the sale of these animals. The number of the principal kinds of livestock raised and sold in the county in 1971 are as follows:

Kinds of livestock	*Number*
Grain-fed cattle sold	50,088
Grain-fed sheep and lambs sold	14,602
Sows farrowed	31,452
Beef cows 2 years old and older	7,173
Milk cows 2 years old and older	1,462
Chickens (Hens and pullets of laying age)	69,799
Commercial broilers produced	2,400
Turkeys	299,300

In recent years the number of farms in Buena Vista County has decreased, and the size of farms has increased. In 1971 there were 1,374 farms in the county, a decrease of 176 since 1965. The average size of farms increased from 229 acres in 1965 to 255 acres in 1971. Most farms are of the cash-grain or livestock type and a few are of the dairy, poultry, or general type. The number of persons living on farms in the county on January 1, 1970, was 5,566.

[4] This section was prepared by DR. ROBERT H. SHAW, professor of climatology, Department of Agronomy, Iowa State University.

TABLE 7.—*Temperature and precipitation data*

[Data from weather station at Storm Lake]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	One year in 10 will have— Less than—	One year in 10 will have— More than—	Average number days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°F	*°F*	*°F*	*°F*	*Inches*	*Inches*	*Inches*		*Inches*
January	27	8	46	−18	0.6	0.1	1.5	20	5
February	31	12	49	−11	.9	.1	2.2	18	4
March	41	22	67	−1	1.6	.5	3.4	14	6
April	59	36	79	20	2.4	1.0	4.3	1	2
May	71	48	86	31	4.0	1.1	6.6	---	---
June	80	58	91	43	4.9	1.9	8.9	---	---
July	86	63	95	50	3.9	1.3	6.7	---	---
August	83	61	93	47	3.5	1.3	5.8	---	---
September	76	52	88	33	2.9	.4	5.6	---	---
October	64	41	82	23	1.9	.1	4.6	(1)	1
November	45	25	66	5	1.0	.1	2.7	3	3
December	32	14	52	−9	.7	.1	1.5	13	4
Year	58	37	96	−19	28.3	16.9	34.4	69	5

[1] Less than one-half day.

TABLE 8.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data from weather station at Storm Lake]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 15	April 22	April 30	May 12	May 21
2 years in 10 later than	April 9	April 16	April 25	May 7	May 16
5 years in 10 later than	March 30	April 5	April 14	April 27	May 6
Fall:					
1 year in 10 earlier than	October 26	October 18	October 12	September 25	September 22
2 years in 10 earlier than	October 31	October 23	October 18	September 30	September 28
5 years in 10 earlier than	November 11	November 3	October 29	October 11	October 8

Literature Cited

(1) American Association of State Highway (and Transportation) Officials. 1970. Standard specifications for highway materials and methods of sampling and testing. Ed. 10, 2 vol., illus.

(2) Lane, George H. 1931. A preliminary pollen analysis of the east McCullock peat bed. Ohio J. Sci. 31: 165–171, illus.

(3) Ruhe, Robert V. 1952. Topographic discontinuities of the Des Moines lobe. Amer. J. Sci. 250: 46–56, illus.

(4) ———— 1959. Important elements in the classification of the Wisconsin glacial stage: a discussion. J. Geol. 67: 585–593.

(5) ———— 1969. Quaternary landscapes in Iowa. Iowa State Univ. Press, Ames, Iowa. 255 pp., illus.

(6) ————, Rubin, Meyer, and Scholtes, W. H. 1957. Late Pleistocene radiocarbon chronology in Iowa. Amer. J. Sci. 255: 671–689, illus.

(7) ———— and Scholtes, W. H. 1956. Ages and development of soil landscapes in relation to climatic and vegetational changes in Iowa. Soil Sci. Soc. Amer. Proc. 20: 264–273, illus.

(8) Simonson, G. H., Prill, R. C., and Riecken, F. F. 1957. Free iron distribution in some poorly drained prairie soils in Iowa. Iowa Acad. Sci. 64: 385–392.

(9) United States Department of Agriculture. 1961. Land capability classification. Agric. Handb. 210.

(10) United States Department of Agriculture. 1951. Soil survey manual. Agric. Handb. 18, 503 pp., illus.

(11) ———— 1960. Soil classification, a comprehensive system, 7th approximation. 256 pp., illus. (Supplements issued in March 1967 and September 1968)

(12) United States Department of Agriculture and Iowa Department of Agriculture. 1971. Annual farm census. Prepared by Iowa Crop and Livest. Rep. Serv., Bull. No. 92 AG, 33 pp., illus.

(13) Walker, P. H. and Brush, Grace S. 1963. Observations on bog and pollen stratigraphy of the Des Moines glacial lobe of Iowa. Iowa Acad. Sci. 70: 253–260, illus.

(14) Wegerslev, C. H. and Walpole, T. 1909. Past and present of Buena Vista County.

(15) Wright, H. E., Jr. and Ruhe, R. V. 1965. Glaciation of Minnesota and Iowa. Rev. vol. for 7th Congr. Int. Assoc. for Quaternary Res.: 29–41, illus. Princeton Univ. Press, Princeton, N.J.

Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field mositure capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bearing capacity. The ability of a soil to support loads which may be applied.

Bench. A high, shelflike land feature.

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Compressibility. The property compressing vertically under load without lateral movement and with a proportional decrease in air or moisture.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically received high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage resul,ts from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Droughty soil. Soil that has less available water capacity than is normally needed for crops. The water table is below the plant rooting zone in droughty soils.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gradation, soil, The distribution of different sized particles in a given soil.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is

mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner color than those in the A horizon, or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Leaching. The removal of soluble material from soil or other material by percolating water.

Loess. Fine grained material, dominately of silt-sized particles, deposited by wind.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: Abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material mixed with mineral soil material. The content of organic matter is more than 20 percent.

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by water that originated mainly from the melting of glacial ice. Glacial outwash is commonly in valleys on landforms known as valley trains, outwash terraces, eskers, kame terraces, kames, outwash fans, or deltas.

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Percolation. The downward movement of water through the soil.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Shear strength. The resistance of a soil to stresses that cause or tend to cause parts of the soil to slide relative to each other in a direction parallel to their plane of contact.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the series to which it belongs. A technical description of a representative profile is part of the descriptive material for the soil series. In the section "Use and Management of the Soils," management for crops is discussed by capability units, environmental plantings are discussed, and information on use of the soils for wildlife habitat is presented.

Map symbol	Mapping unit	Described on page	Capability unit		Environmental planting group
			Symbol	Page	Number
6	Okoboji silty clay loam, 0 to 1 percent slopes	28	IIIw-1	47	2
27C	Terril loam, 4 to 9 percent slopes	37	IIIe-1	46	1
31	Afton silty clay loam, 0 to 2 percent slopes	10	IIw-2	44	2
32	Spicer silty clay loam, 0 to 2 percent slopes	34	IIw-2	44	2
34B	Estherville sandy loam, 2 to 5 percent slopes	20	IIIe-4	47	4
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	20	IIIe-4	47	4
55	Nicollet loam, 1 to 3 percent slopes	28	I-1	42	1
62C	Storden loam, 5 to 9 percent slopes	35	IIIe-1	46	3
62D	Storden loam, 9 to 14 percent slopes	35	IIIe-2	46	3
62E	Storden loam, 14 to 18 percent slopes	35	IVe-1	48	3
62F	Storden loam, 18 to 25 percent slopes	35	VIe-1	49	3
62G	Storden loam, 25 to 40 percent slopes	35	VIIe-1	50	3
73C	Salida gravelly sandy loam, 5 to 9 percent slopes	33	IVs-1	48	4
73D	Salida gravelly sandy loam, 9 to 14 percent slopes	33	VIs-1	49	4
77B	Sac silty clay loam, loam substratum, 2 to 5 percent slopes	32	IIe-1	42	1
77C2	Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	32	IIIe-1	46	1
78B	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	32	IIe-1	42	1
78C2	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded	32	IIIe-1	46	1
91	Primghar silty clay loam, 0 to 2 percent slopes	29	I-1	42	1
91B	Primghar silty clay loam, 2 to 4 percent slopes	29	IIe-2	42	1
92	Marcus silty clay loam, 0 to 2 percent slopes	26	IIw-2	44	2
95	Harps loam, 0 to 2 percent slopes	23	IIw-4	44	2
107	Webster silty clay loam, 0 to 2 percent slopes	40	IIw-2	44	2
108	Wadena loam, moderately deep, 0 to 2 percent slopes	39	IIs-1	45	1
108B	Wadena loam, moderately deep, 2 to 5 percent slopes	39	IIe-3	43	1
108C2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded	39	IIIe-3	47	1
133	Colo silty clay loam, 0 to 2 percent slopes	16	IIw-1	43	2
138B	Clarion loam, 2 to 5 percent slopes	14	IIe-1	42	1
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	14	IIIe-1	46	1
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	14	IIIe-2	46	1
175B	Dickinson fine sandy loam, 2 to 5 percent slopes	19	IIIe-4	47	1
202	Cylinder loam, moderately deep, 0 to 2 percent slopes	18	IIs-2	45	1
203	Cylinder loam, deep, 0 to 2 percent slopes	18	I-2	42	1
236F	Lester loam, 18 to 25 percent slopes	25	VIe-1	49	1
236G	Lester loam, 25 to 40 percent slopes	25	VIIe-1	50	1
250B	Clarion silty clay loam, 2 to 5 percent slopes	14	IIe-1	42	1
251	Nicollet silty clay loam, 1 to 3 percent slopes	28	I-1	42	1
259	Biscay clay loam, deep, 0 to 2 percent slopes	11	IIw-3	44	2
274	Rolfe silt loam, 0 to 1 percent slopes	30	IIIw-1	47	2
308B	Wadena loam, deep, 1 to 5 percent slopes	38	IIe-1	42	1
310	Galva silty clay loam, 0 to 2 percent slopes	22	I-1	42	1
310B	Galva silty clay loam, 2 to 5 percent slopes	22	IIe-1	42	1
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	22	IIIe-1	46	1
T310	Galva silty clay loam, benches, 1 to 3 percent slopes	22	I-1	42	1
354	Marsh	26	VIIw-1	50	2
384	Collinwood silty clay loam, 0 to 2 percent slopes	15	IIs-3	45	2
384B	Collinwood silty clay loam, 2 to 5 percent slopes	15	IIe-4	43	2
384C	Collinwood silty clay loam, 5 to 9 percent slopes	16	IIIe-1	46	2
390	Waldorf silty clay loam, 0 to 2 percent slopes	40	IIw-5	45	2
428B	Ely silty clay loam, 2 to 5 percent slopes	19	IIe-2	42	1

Map symbol	Mapping unit	Described on page	Capability unit		Environmental planting group
			Symbol	Page	Number
C458	Millington loam, channeled, 0 to 2 percent slopes	26	Vw-1	49	2
485	Spillville loam, 0 to 2 percent slopes	34	IIw-1	43	1
485B	Spillville loam, 2 to 5 percent slopes	35	IIe-2	42	1
501	Gravel pits	23	VIIs-1	50	4
504	Fill land	21	Vw-2	49	2
506	Wacousta mucky silt loam, 0 to 1 percent slopes	38	IIIw-2	48	2
507	Canisteo silty clay loam, 0 to 2 percent slopes	13	IIw-2	44	2
511	Blue Earth mucky silt loam, 0 to 1 percent slopes	12	IIIw-2	48	2
558	Talcot clay loam, moderately deep, 0 to 2 percent slopes	36	IIw-3	44	2
559	Talcot clay loam, deep, 0 to 2 percent slopes	36	IIw-3	44	2
577B	Everly clay loam, 2 to 5 percent slopes	21	IIe-1	42	1
577C	Everly clay loam, 5 to 9 percent slopes	21	IIIe-1	46	1
577C2	Everly clay loam, 5 to 9 percent slopes, moderately eroded	21	IIIe-1	46	1
585B	Colo-Spillville complex, 2 to 5 percent slopes	16	IIw-1	43	2
C585	Colo-Spillville complex, channeled, 0 to 2 percent slopes	16	Vw-1	49	2
606	Lanyon silty clay loam, 0 to 1 percent slopes	24	IIIw-2	48	2
733	Calco silty clay loam, 0 to 2 percent slopes	12	IIw-1	43	2

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977— 596-966/56

U. S. DEPARTMENT OF AGRICULTURE

Washington, D. C. 20013

Soil Survey of Buena Vista County, Iowa

ERRATUM

The descriptions for ad-hoc map symbols compiled on the detailed map sheets were inadvertently omitted from the Conventional and Special Symbols Legend of the soil survey publication.

Glacial till outcrop (< 2 acres)------------------- #

Moderately or highly calcareous spot (< 2 acres)---- ¤

Small area of Okoboji soils (< 2 acres)------------ ⦶

Small hump of well drained soil (< 2 acres)-------- ǂ

Made land -- ∵

Small area of Rolfe silt loam ----------------------- ⊕

This erratum should be inserted in each publication opposite the Conventional and Special Symbols Legend located at the beginning of the detailed map sheets of the soil survey publication.

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

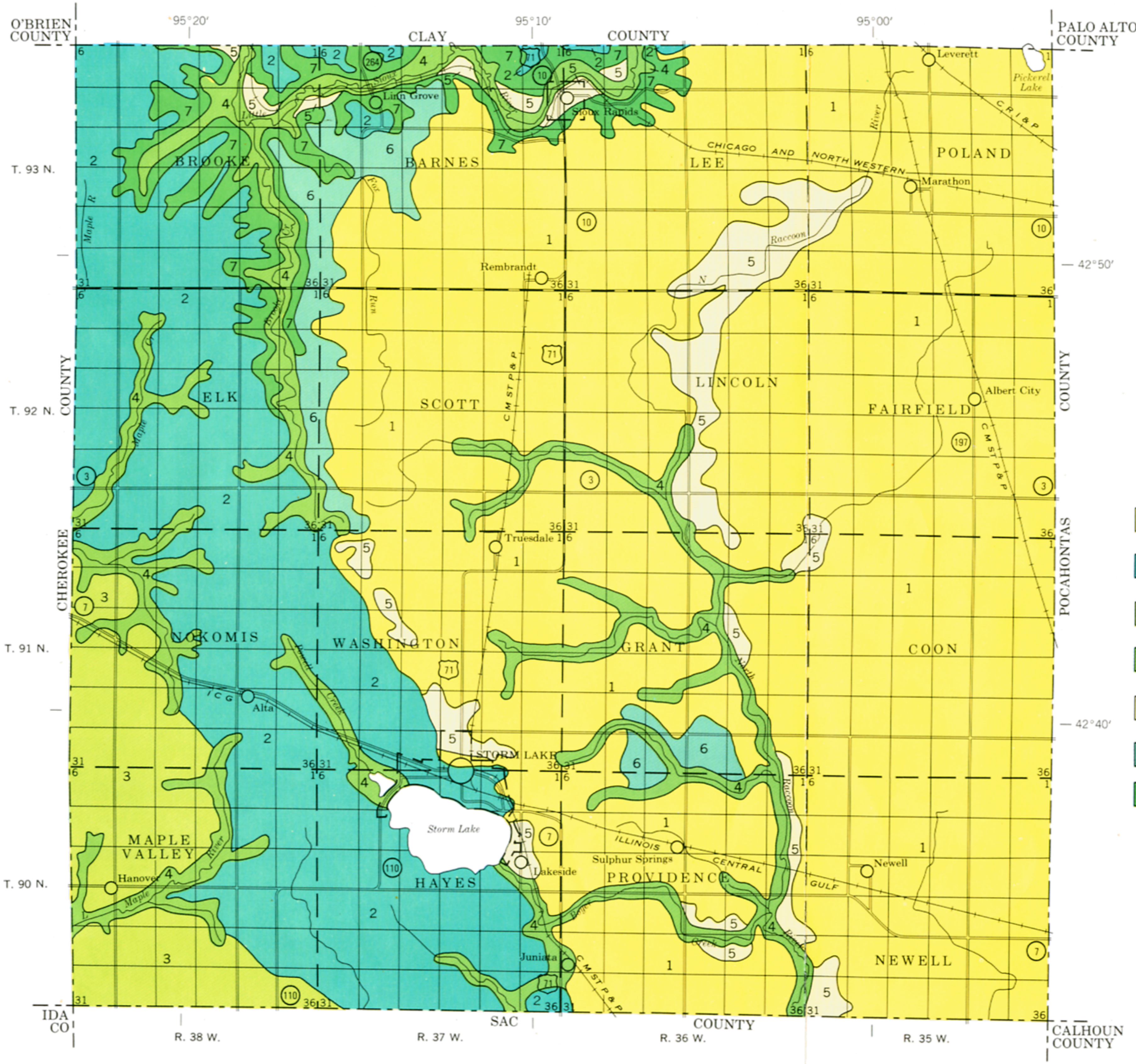
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY
DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

GENERAL SOIL MAP

BUENA VISTA COUNTY, IOWA

Scale 1:190,080

1 0 1 2 3 4 Miles



SOIL ASSOCIATIONS *

1	Clarion-Nicollet-Canisteo association: Well-drained to poorly drained, medium-textured and moderately fine textured, nearly level to moderately sloping soils on uplands
2	Sac-Primghar-Galva association: Well-drained and somewhat poorly drained, moderately fine textured, nearly level to moderately sloping soils on loess-mantled uplands
3	Galva-Sac-Primghar association: Well-drained and somewhat poorly drained, moderately fine textured, nearly level to moderately sloping soils on loess-mantled uplands
4	Colo-Calco-Spillville association: Poorly drained and somewhat poorly drained, moderately fine textured and medium-textured, nearly level and gently sloping soils on bottom lands
5	Wadena-Talcot-Cylinder association: Well-drained to very poorly drained, medium-textured and moderately fine textured, nearly level to moderately sloping soils on outwash plains and terraces
6	Waldorf-Collinwood-Clarion association: Poorly drained to well-drained, medium-textured to fine-textured, nearly level to moderately sloping soils on uplands
7	Storden association: Somewhat excessively drained, medium-textured, moderately sloping to very steep soils on uplands

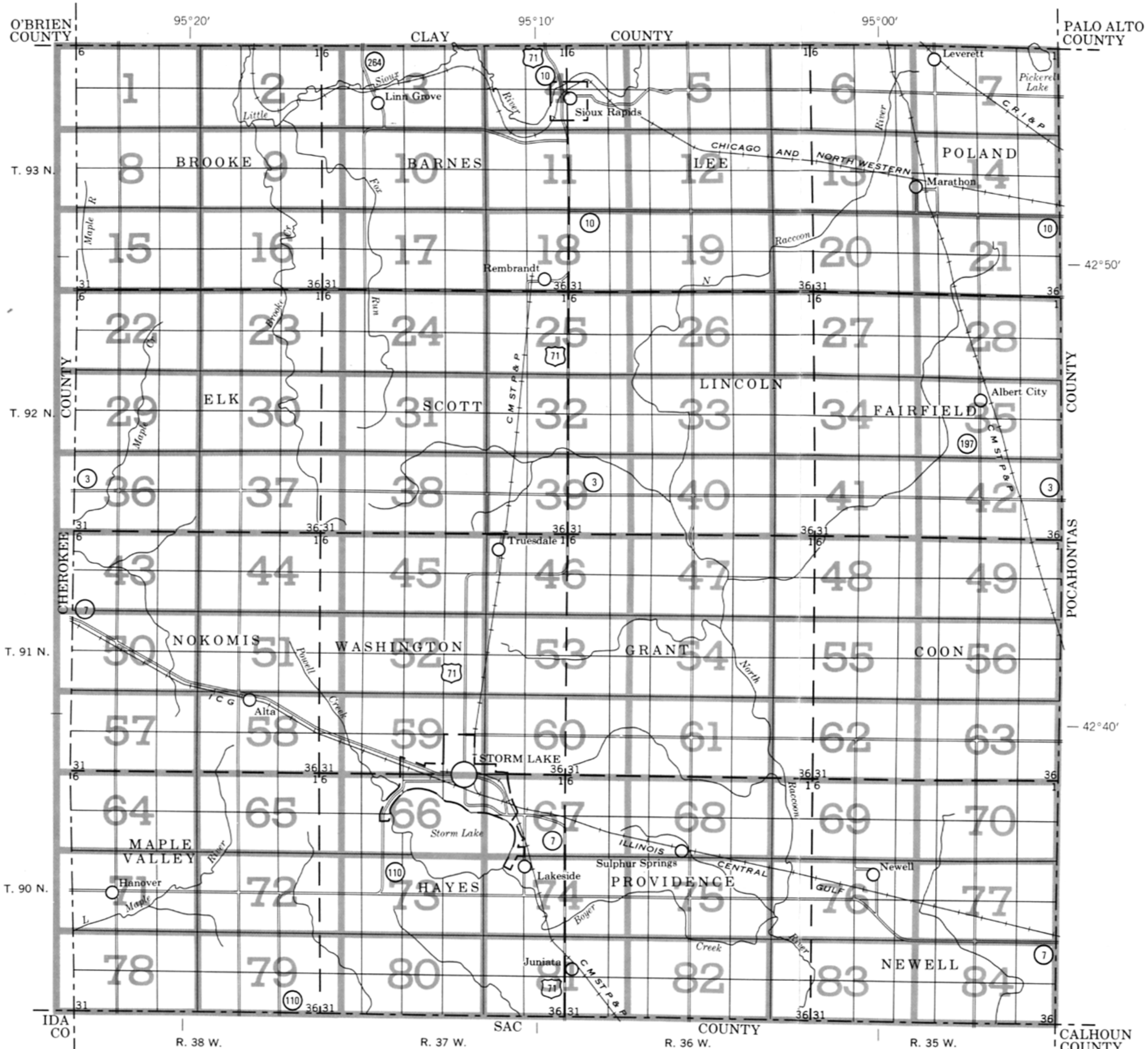
* Texture in the descriptive name refers to the surface layer of the major soils in each association.

Compiled 1976

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36



INDEX TO MAP SHEETS
BUENA VISTA COUNTY, IOWA

Scale 1:190,080

1 0 1 2 3 4 Miles

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

BUENA VISTA COUNTY, IOWA

IOWA AGRICULTURE AND HOME ECONOMICS EXPERIMENT STATION
COOPERATIVE EXTENSION SERVICE, IOWA STATE UNIVERSITY
DEPARTMENT OF SOIL CONSERVATION, STATE OF IOWA

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool — Davis Airstrip; FLOOD POOL LINE

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate — 79
- Federal — 410
- State — 52
- County, farm or ranch — 378

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small — water; w

PITS

- Gravel pit
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — GAS
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water; w
- Intermittent — int; i

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS — CeA; FoB2

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown) — S

MISCELLANEOUS

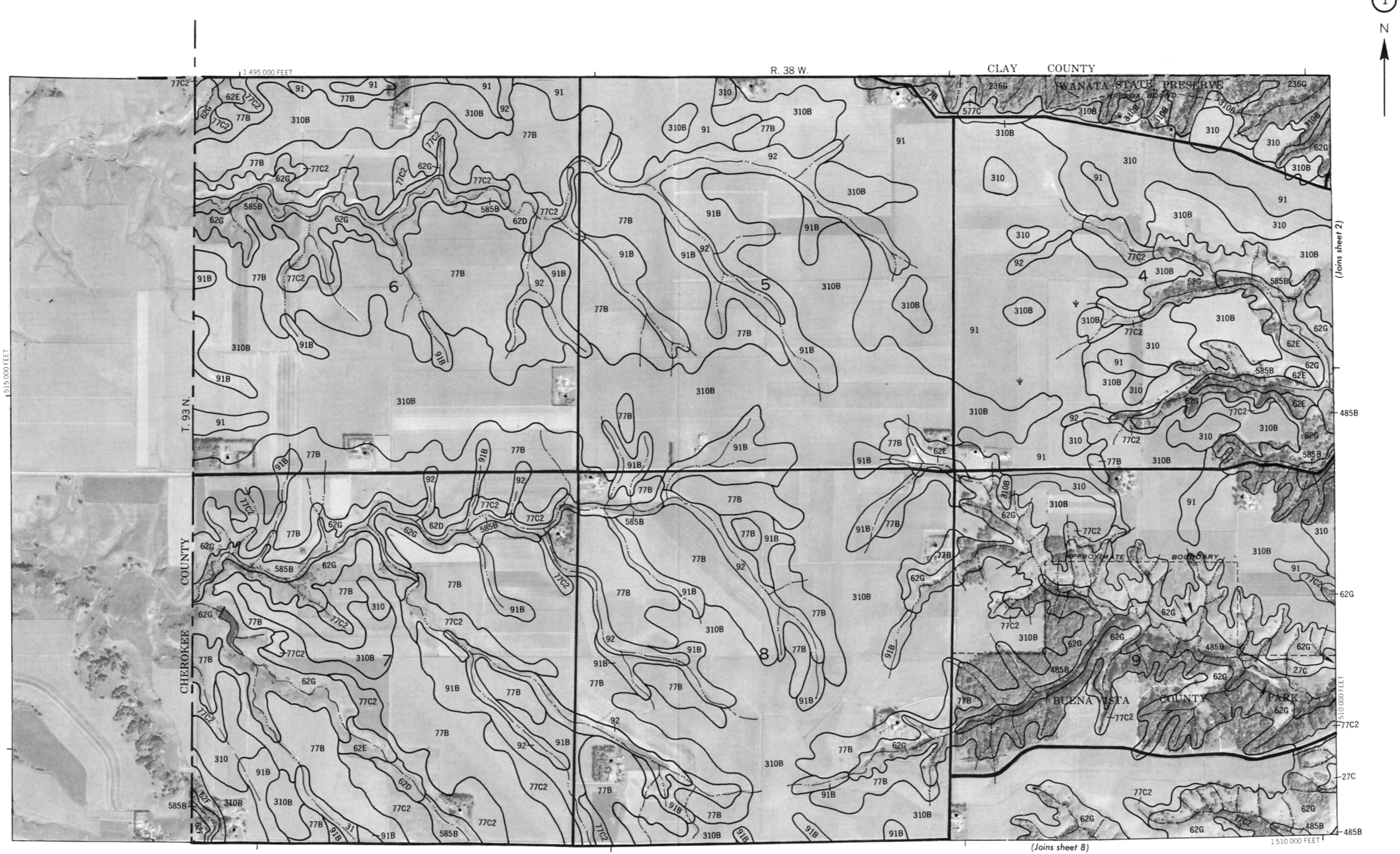
- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic)
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot

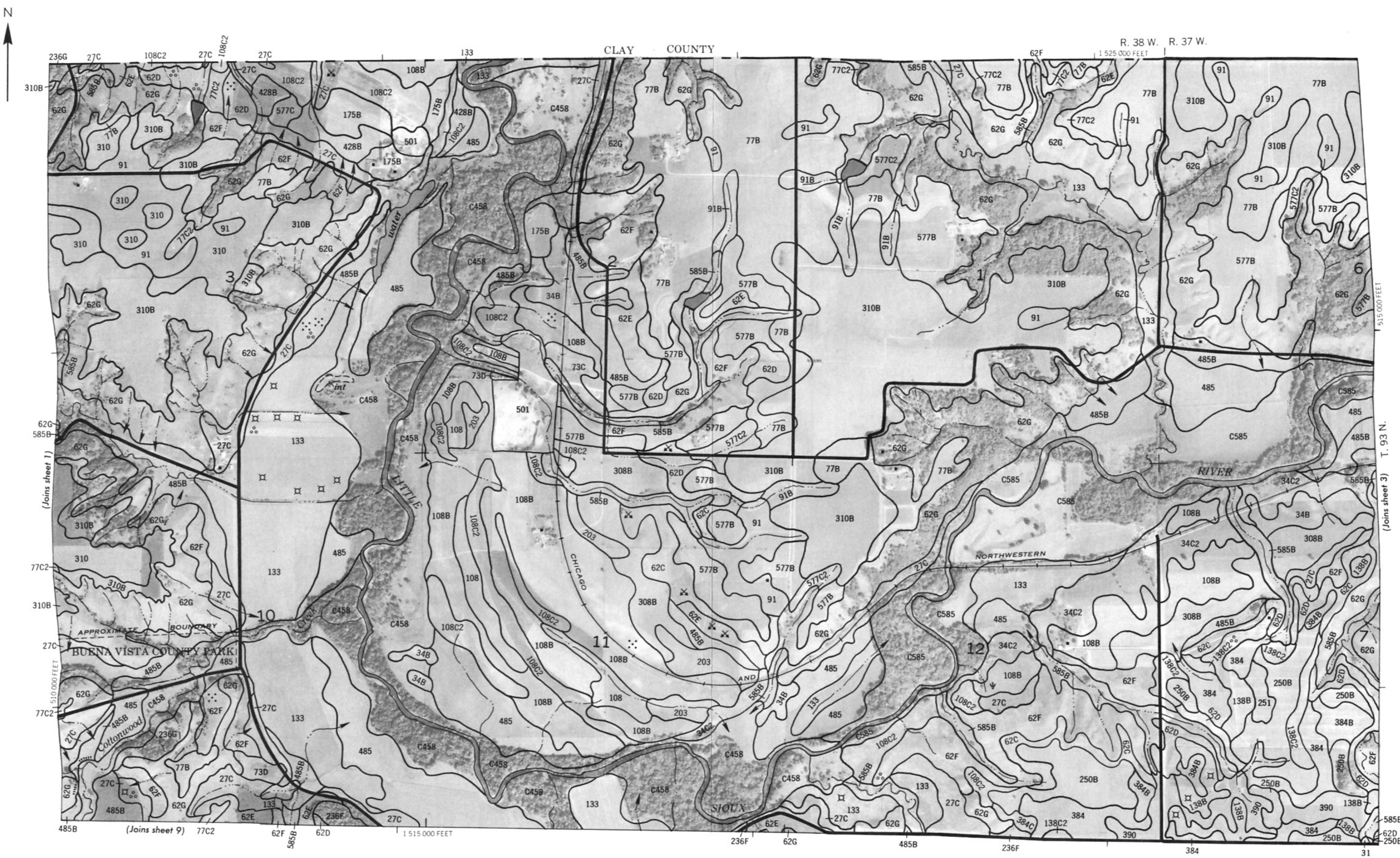
SOIL LEGEND

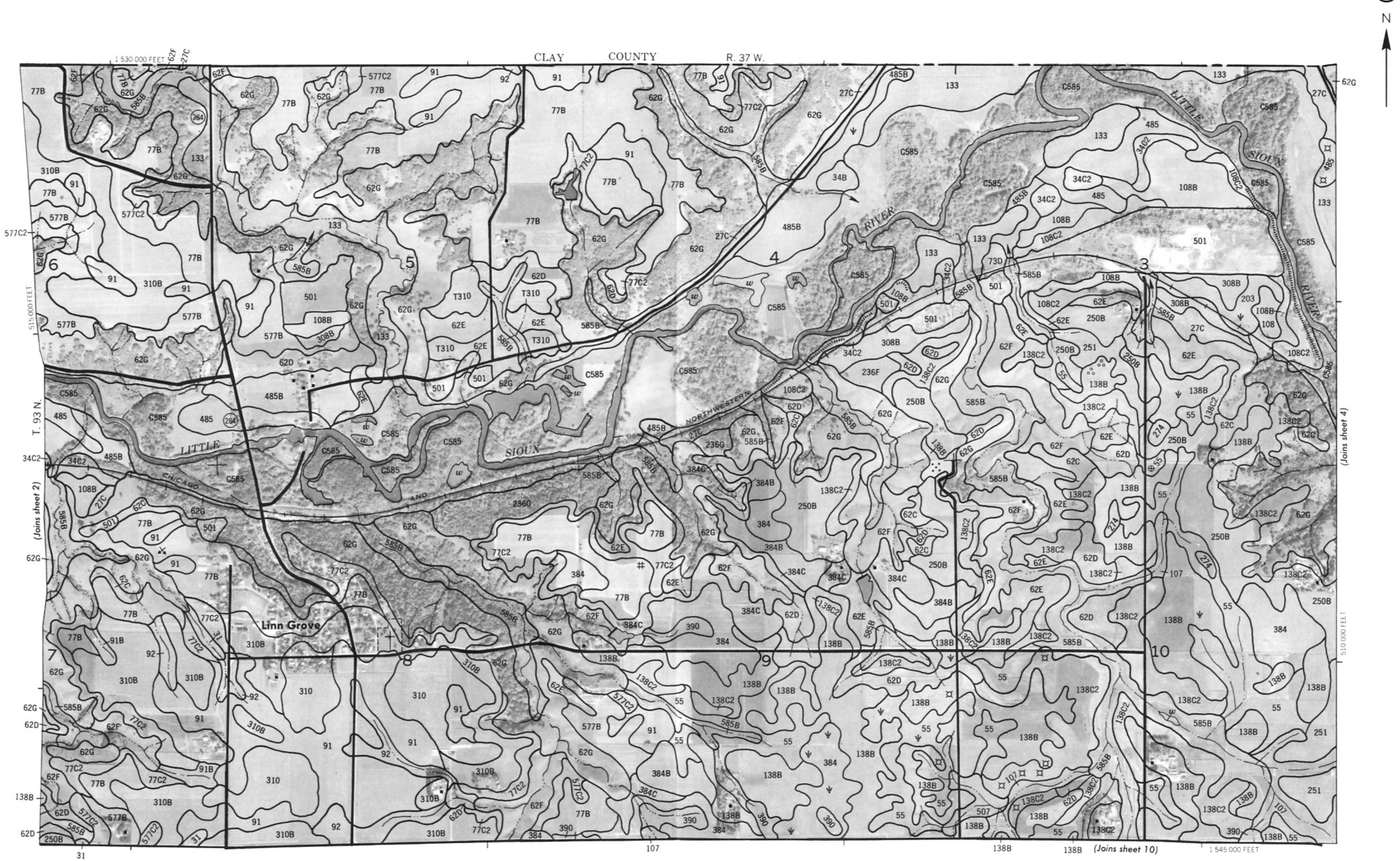
Symbols consist of numbers or a combination of numbers and letters, for example 31, 108C2, 138B. The 2 or 3 digit number designates the kind of soil or land type. A capital letter B, C, D, E, F or G following a number indicates the class of slope. Symbols without a slope letter are those for units that are nearly level. A final number 2 following a letter indicates that the soil is moderately eroded. The capital C or T used as a prefix indicates a channeled phase or a bench phase respectively.

SYMBOL	NAME
6	Okoboji silty clay loam, 0 to 1 percent slopes
27C	Terril loam, 4 to 9 percent slopes
31	Afton silty clay loam, 0 to 2 percent slopes
32	Spicer silty clay loam, 0 to 2 percent slopes
34B	Estherville sandy loam, 2 to 5 percent slopes
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded
55	Nicollet loam, 1 to 3 percent slopes
62C	Storden loam, 5 to 9 percent slopes
62D	Storden loam, 9 to 14 percent slopes
62E	Storden loam, 14 to 18 percent slopes
62F	Storden loam, 18 to 25 percent slopes
62G	Storden loam, 25 to 40 percent slopes
73C	Salida gravelly sandy loam, 5 to 9 percent slopes
73D	Salida gravelly sandy loam, 9 to 14 percent slopes
77B	Sac silty clay loam, loam substratum, 2 to 5 percent slopes
77C2	Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded
78B	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes
78C2	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded
91	Primghar silty clay loam, 0 to 2 percent slopes
91B	Primghar silty clay loam, 2 to 4 percent slopes
92	Marcus silty clay loam, 0 to 2 percent slopes
95	Harps loam, 0 to 2 percent slopes
107	Webster silty clay loam, 0 to 2 percent slopes
108	Wadena loam, moderately deep, 0 to 2 percent slopes
108B	Wadena loam, moderately deep, 2 to 5 percent slopes
108C2	Wadena loam, moderately deep, 5 to 9 percent slopes, moderately eroded
133	Colo silty clay loam, 0 to 2 percent slopes
138B	Clarion loam, 2 to 5 percent slopes
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded
175B	Dickinson fine sandy loam, 2 to 5 percent slopes
202	Cylinder loam, moderately deep, 0 to 2 percent slopes
203	Cylinder loam, deep, 0 to 2 percent slopes
236F	Lester loam, 18 to 25 percent slopes
236G	Lester loam, 25 to 40 percent slopes
250B	Clarion silty clay loam, 2 to 5 percent slopes
251	Nicollet silty clay loam, 1 to 3 percent slopes
259	Biscay clay loam, deep, 0 to 2 percent slopes
274	Rolfe silt loam, 0 to 1 percent slopes
308B	Wadena loam, deep, 1 to 5 percent slopes
310	Galva silty clay loam, 0 to 2 percent slopes
310B	Galva silty clay loam, 2 to 5 percent slopes
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded
T310	Galva silty clay loam, benches, 1 to 3 percent slopes
354	Marsh
384	Collinwood silty clay loam, 0 to 2 percent slopes
384B	Collinwood silty clay loam, 2 to 5 percent slopes
384C	Collinwood silty clay loam, 5 to 9 percent slopes
390B	Waldorf silty clay loam, 0 to 2 percent slopes
428B	Ely silty clay loam, 2 to 5 percent slopes
C458	Millington loam, channeled, 0 to 2 percent slopes
485	Spillville loam, 0 to 2 percent slopes
485B	Spillville loam, 2 to 5 percent slopes
501	Gravel pits
504	Fill land
506	Wacousta mucky silt loam, 0 to 1 percent slopes
507	Canisteo silty clay loam, 0 to 2 percent slopes
511	Blue Earth mucky silt loam, 0 to 1 percent slopes
558	Talcot clay loam, moderately deep, 0 to 2 percent slopes
559	Talcot clay loam, deep, 0 to 2 percent slopes
577B	Everly clay loam, 2 to 5 percent slopes
577C	Everly clay loam, 5 to 9 percent slopes
577C2	Everly clay loam, 5 to 9 percent slopes, moderately eroded
585B	Colo-Spillville complex, 2 to 5 percent slopes
C585	Colo-Spillville complex, channeled, 0 to 2 percent slopes
606	Lanyon silty clay loam, 0 to 1 percent slopes
733	Calco silty clay loam, 0 to 2 percent slopes

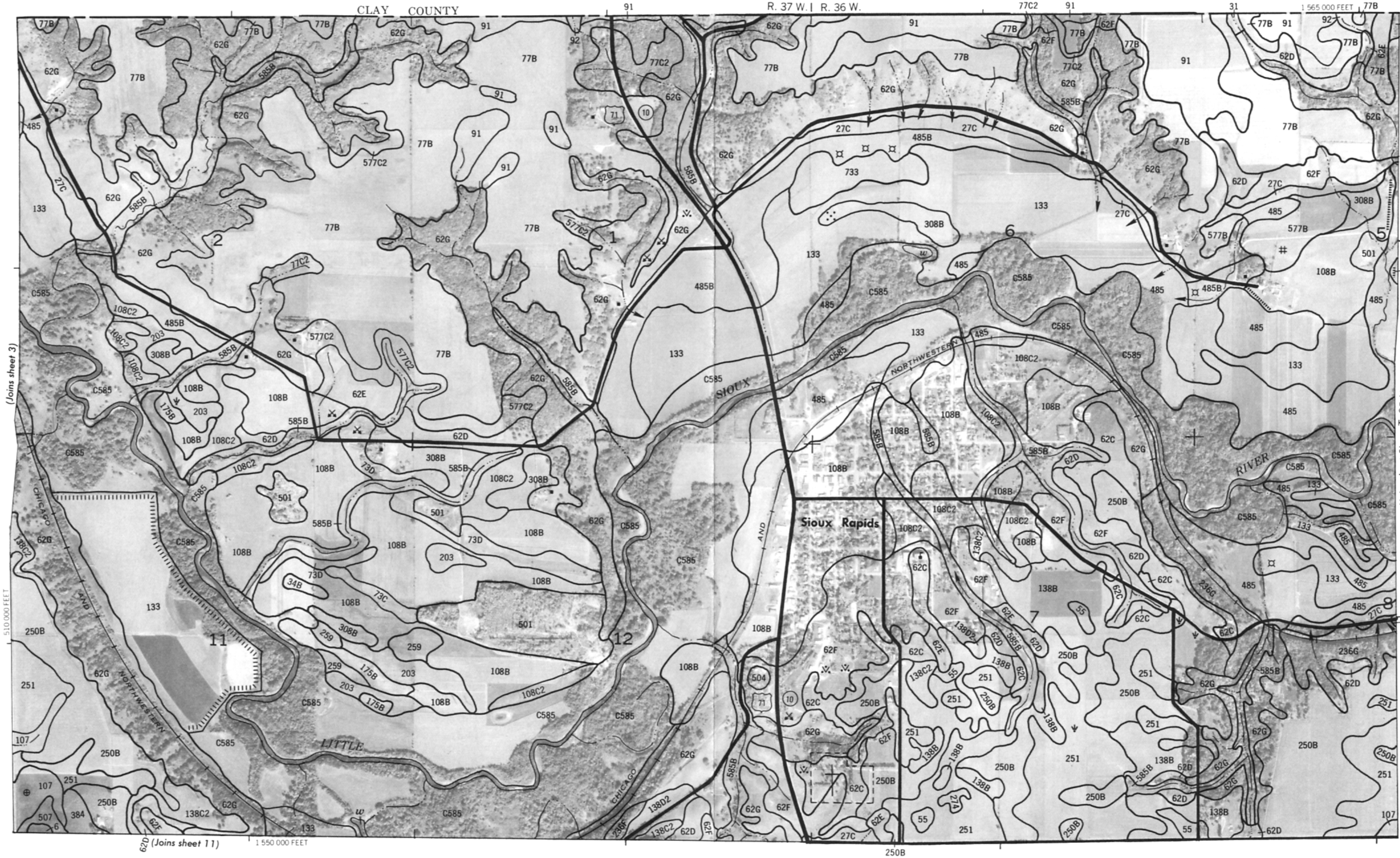
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 1



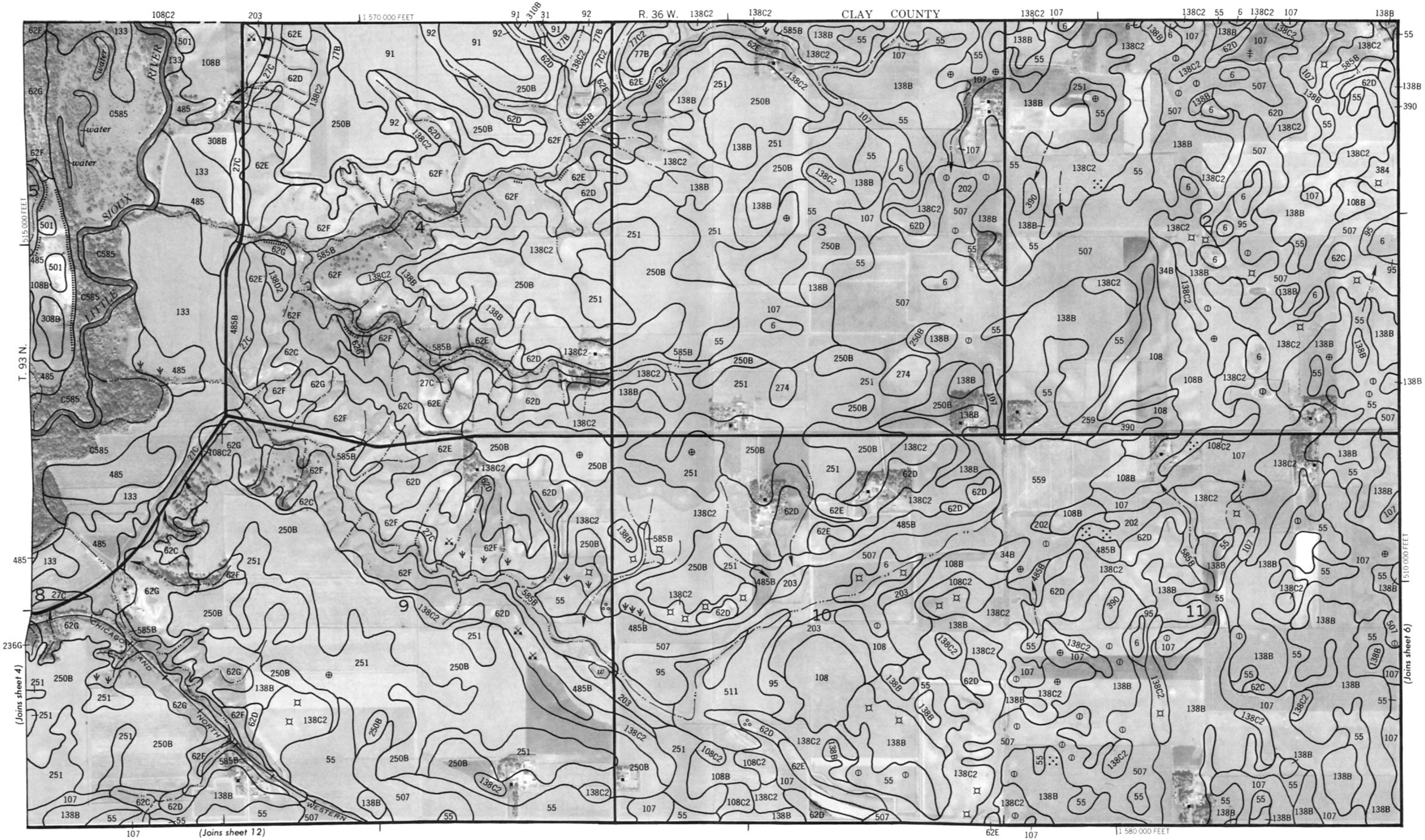

N
CLAY COUNTY
R. 38 W.
R. 37 W.
T. 93 N.
1 525 000 FEET
515 000 FEET
510 000 FEET
1 515 000 FEET
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 9)
LITTLE
SIOUX
RIVER
CHICAGO
AND
NORTHWESTERN
APPROXIMATE BOUNDARY
BUENA VISTA COUNTY PARK
Cottonwood
Creek
water
int
1
2
3
6
7
10
11
12


3
N
CLAY COUNTY
R. 37 W.
T. 93 N.
1 530 000 FEET
1 545 000 FEET
515 000 FEET
510 000 FEET
LITTLE SIOUX RIVER
CHICAGO AND NORTHWESTERN
Linn Grove
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 10)

N

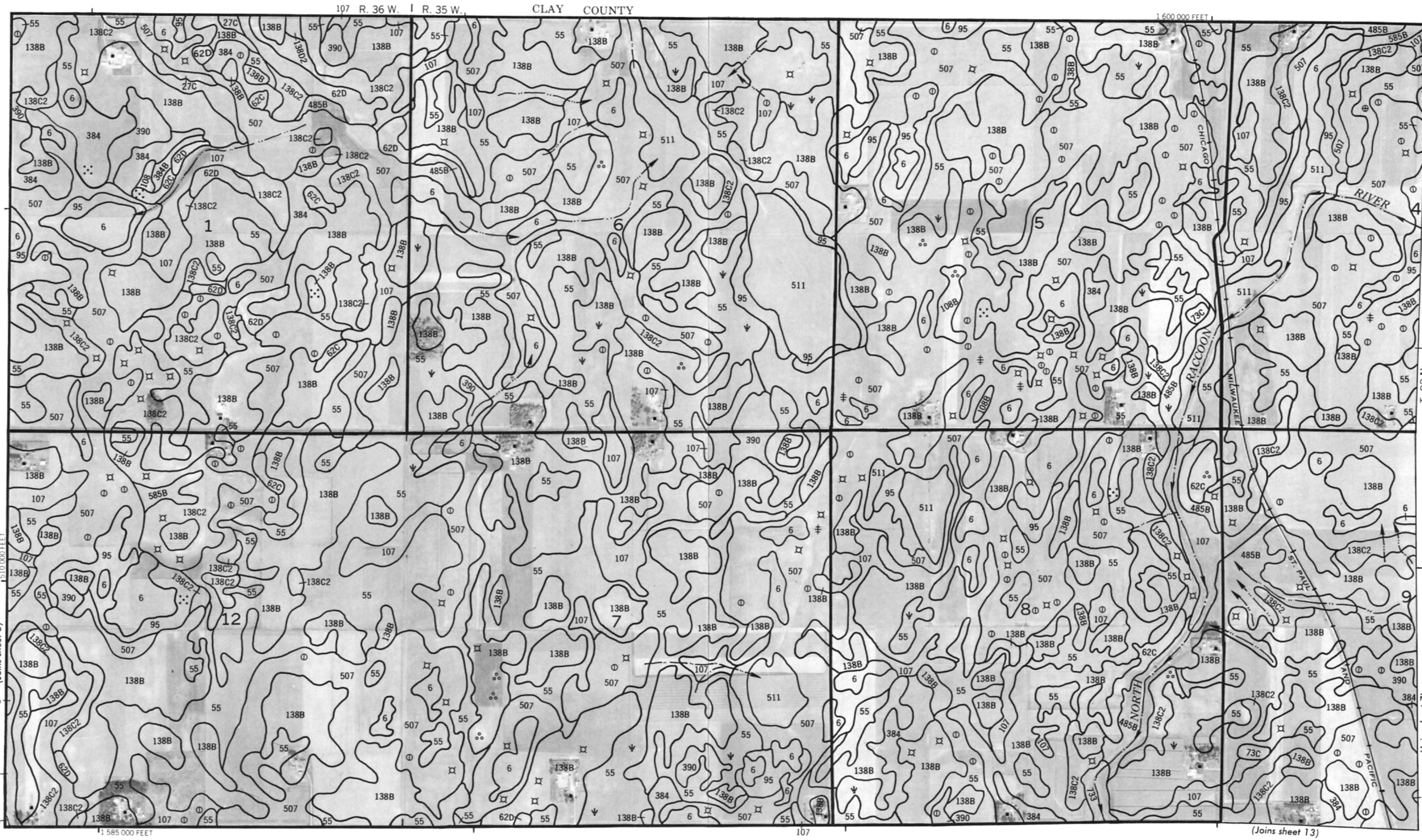

CLAY COUNTY
R. 37 W.
R. 36 W.
1 565 000 FEET
515 000 FEET
T. 93 N.
(Joins sheet 3)
(Joins sheet 5)
(Joins sheet 11)
510 000 FEET
1 550 000 FEET
Sioux Rapids
SIOUX
RIVER
LITTLE
CHICAGO AND NORTHWESTERN
NORTHWESTERN
1
2
5
6
7
8
11
12

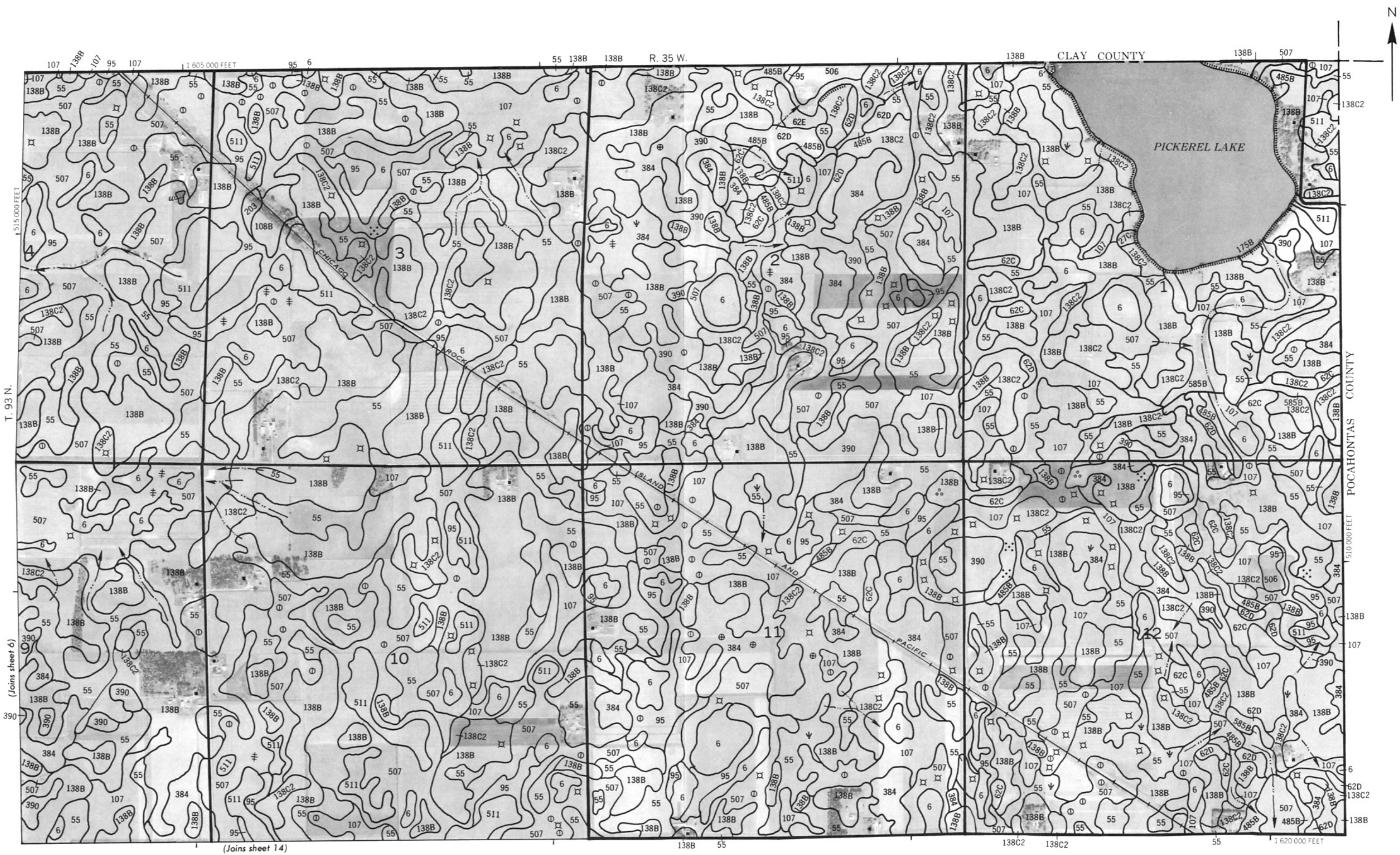
N


CLAY COUNTY
R. 36 W.
T. 93 N.
1 570 000 FEET
1 580 000 FEET
515 000 FEET
510 000 FEET
LITTLE SIOUX RIVER
water
CHICAGO AND NORTH WESTERN
(Joins sheet 4)
(Joins sheet 6)
(Joins sheet 12)

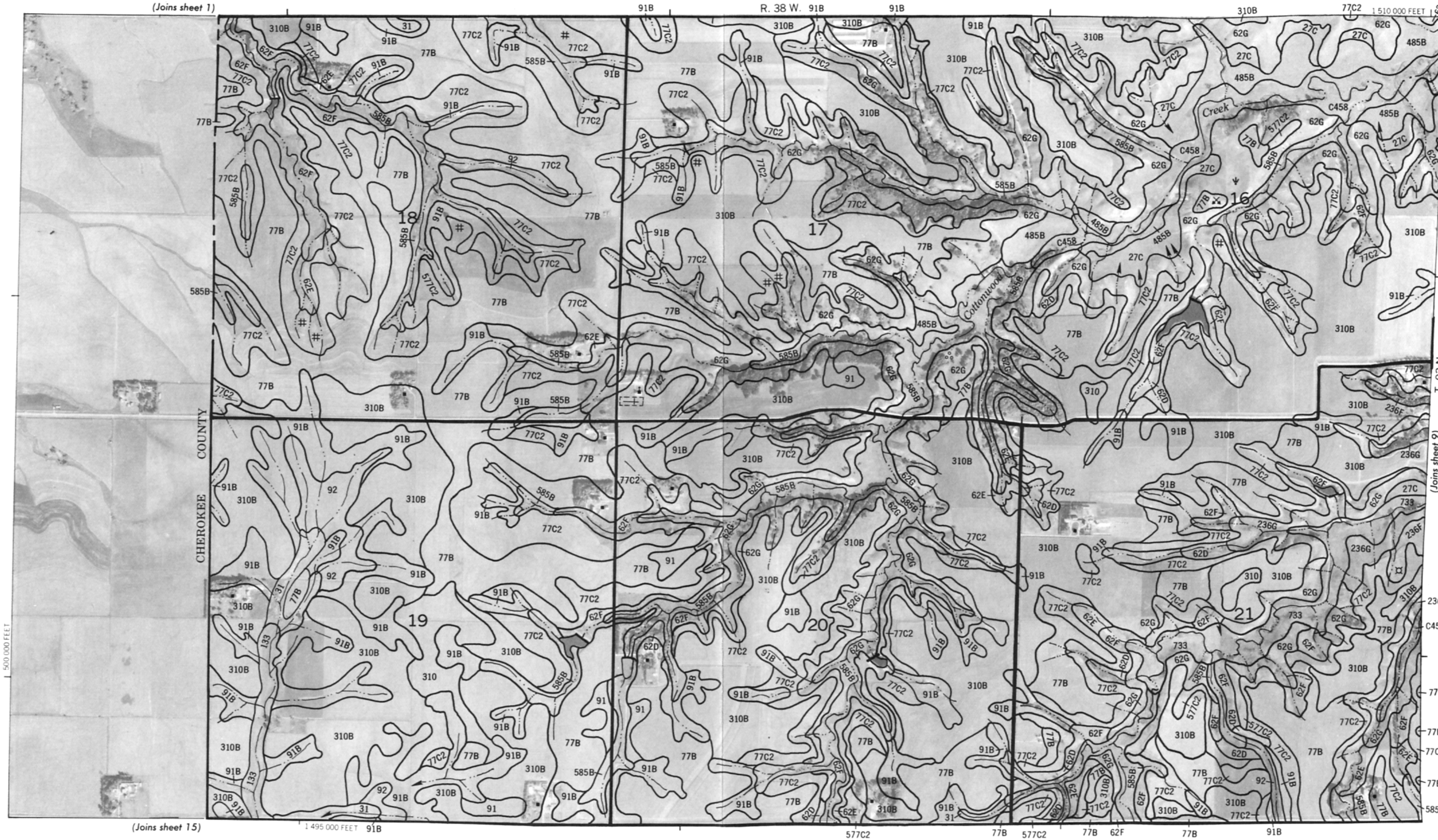
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 6

N




N
CLAY COUNTY
POCAHONTAS COUNTY
PICKEREL LAKE
R. 35 W.
T. 93 N.
CHICAGO ROCK ISLAND AND PACIFIC
1 605 000 FEET
1 620 000 FEET
515 000 FEET
510 000 FEET
(Joins sheet 6)
(Joins sheet 14)

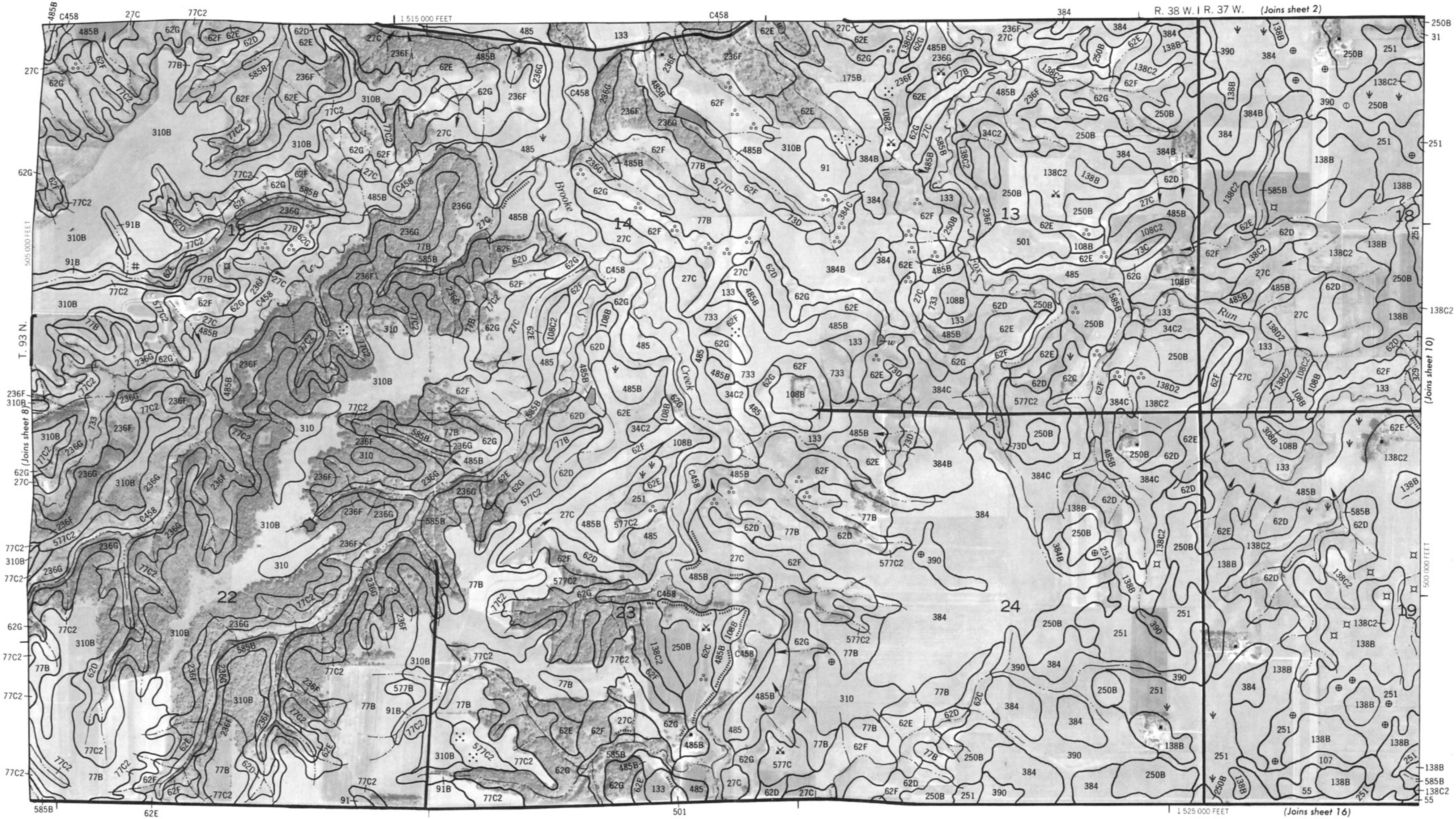
N


(Joins sheet 1)
R. 38 W.
1 510 000 FEET
505 000 FEET
T. 93 N.
(Joins sheet 9)
(Joins sheet 15)
1 495 000 FEET
500 000 FEET
CHEROKEE COUNTY
Cottonwood
Creek
16
17
18
19
20
21

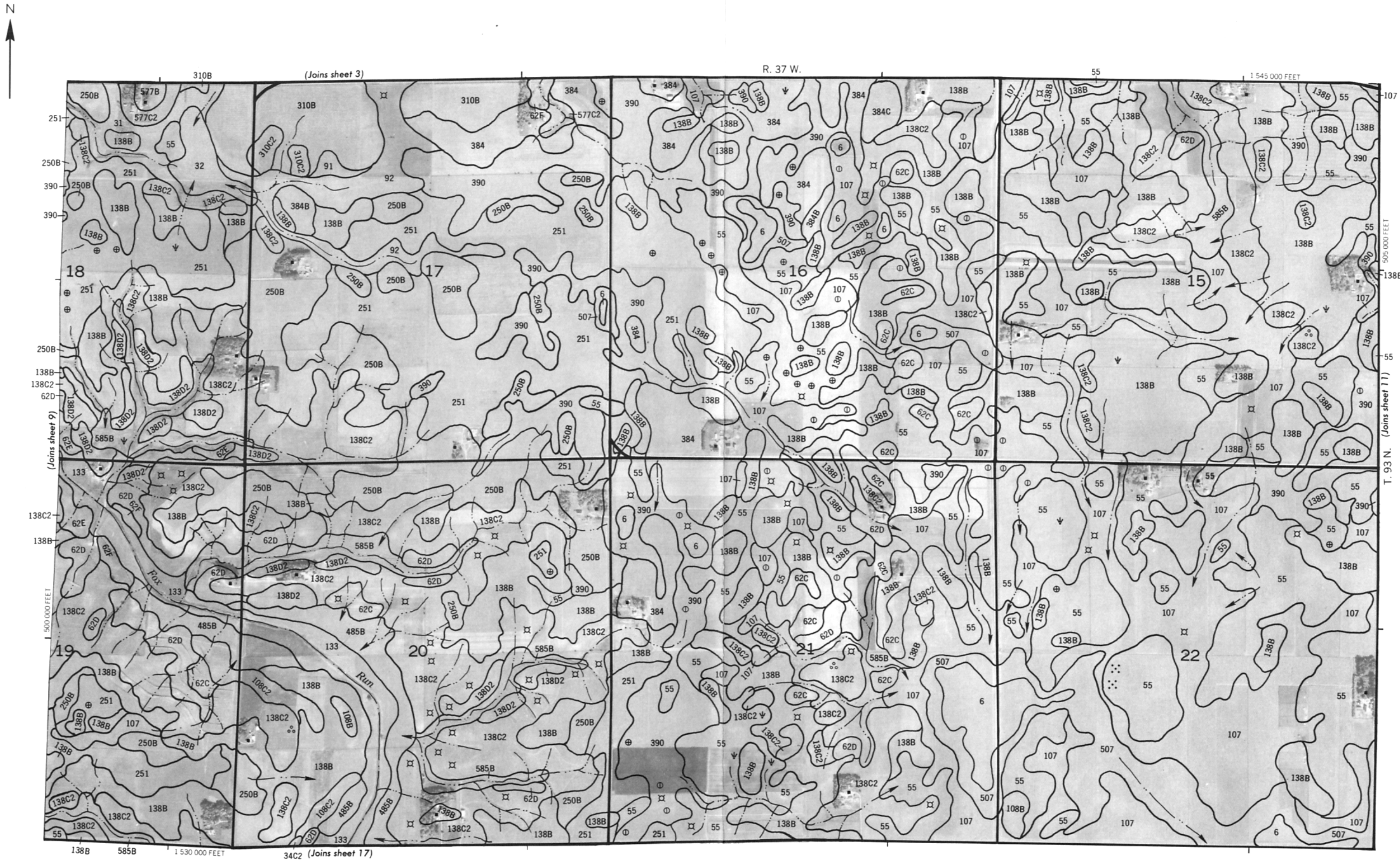
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 9

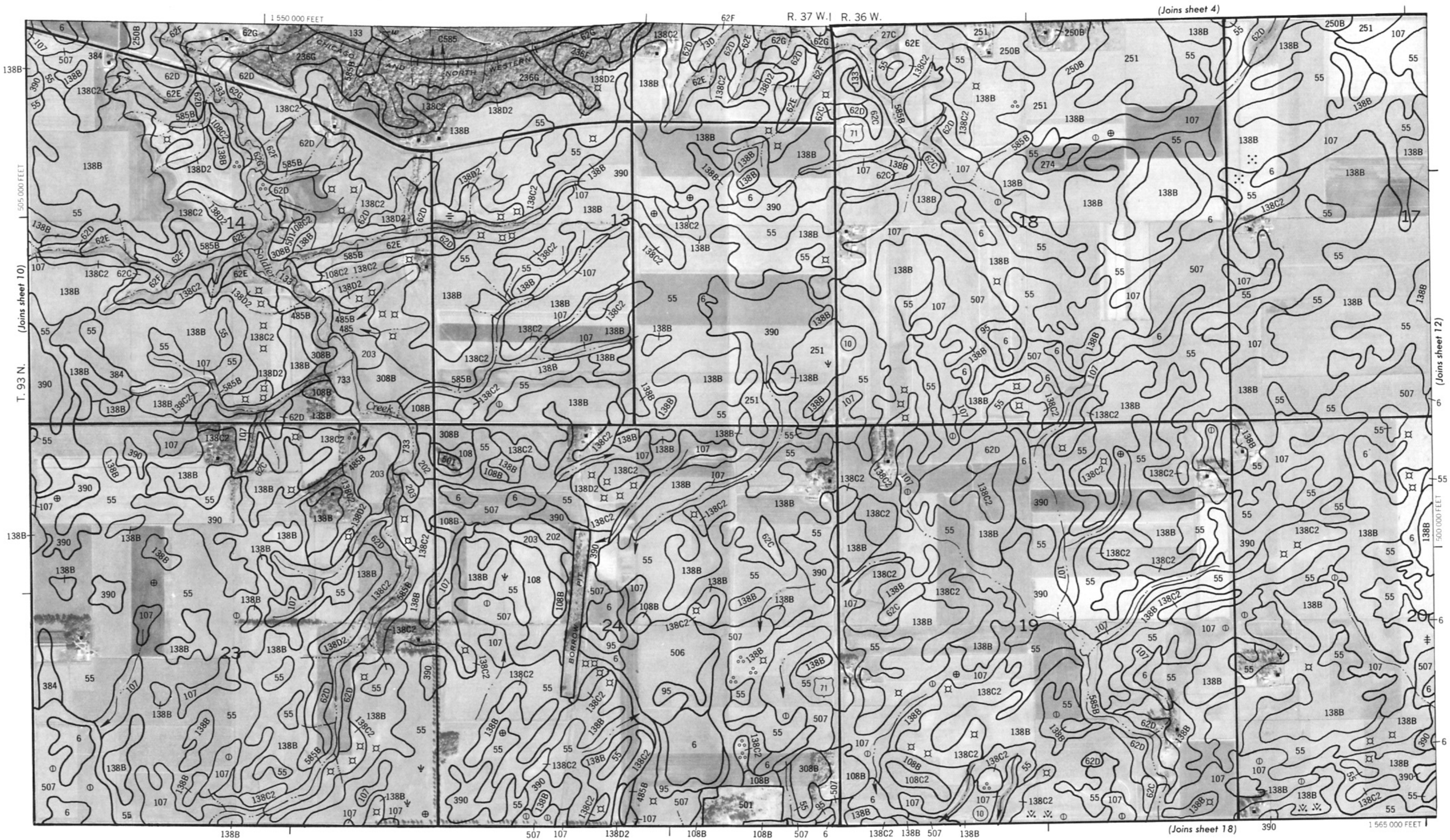
9

N

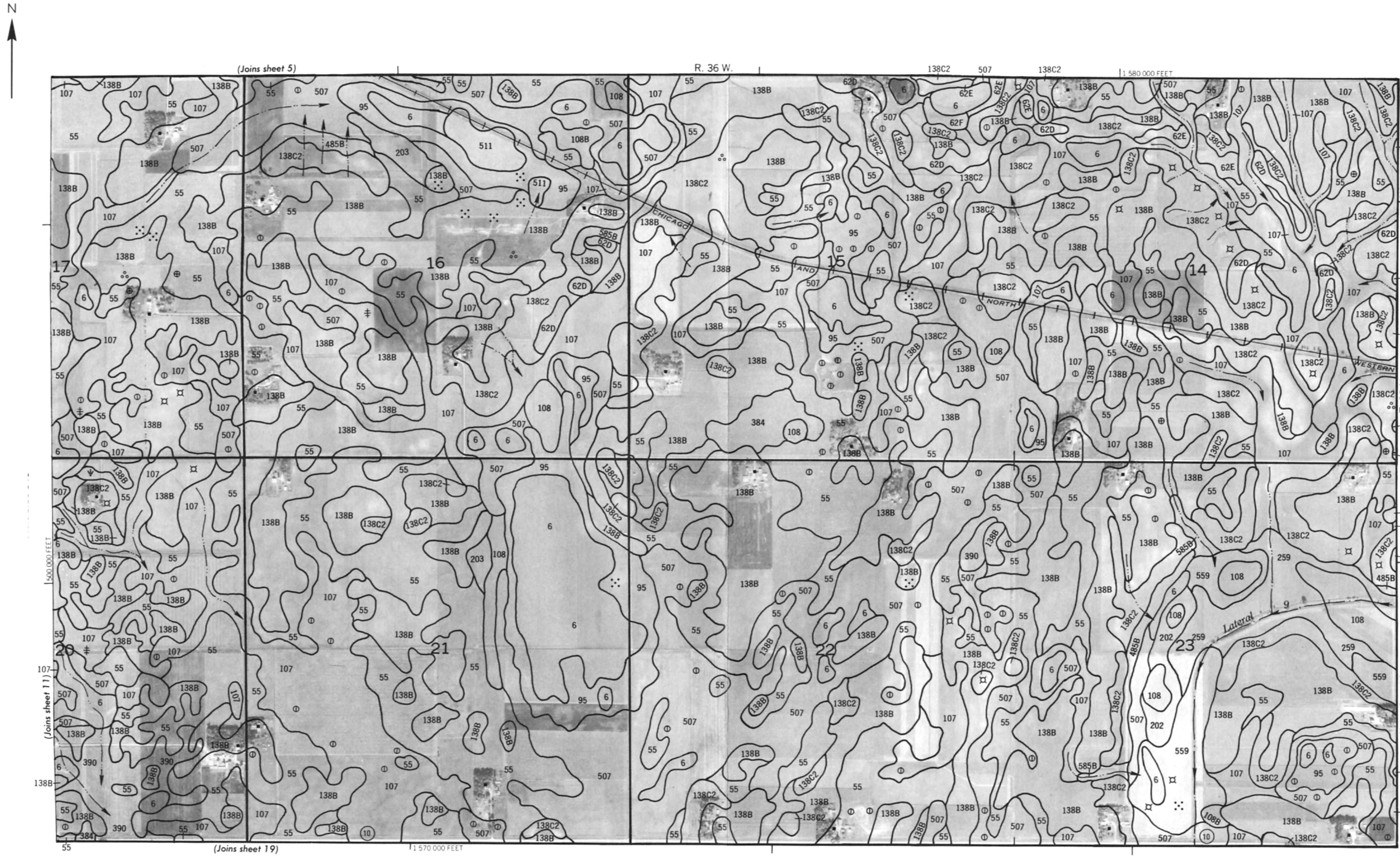


BUENA VISTA COUNTY, IOWA — SHEET NUMBER 10

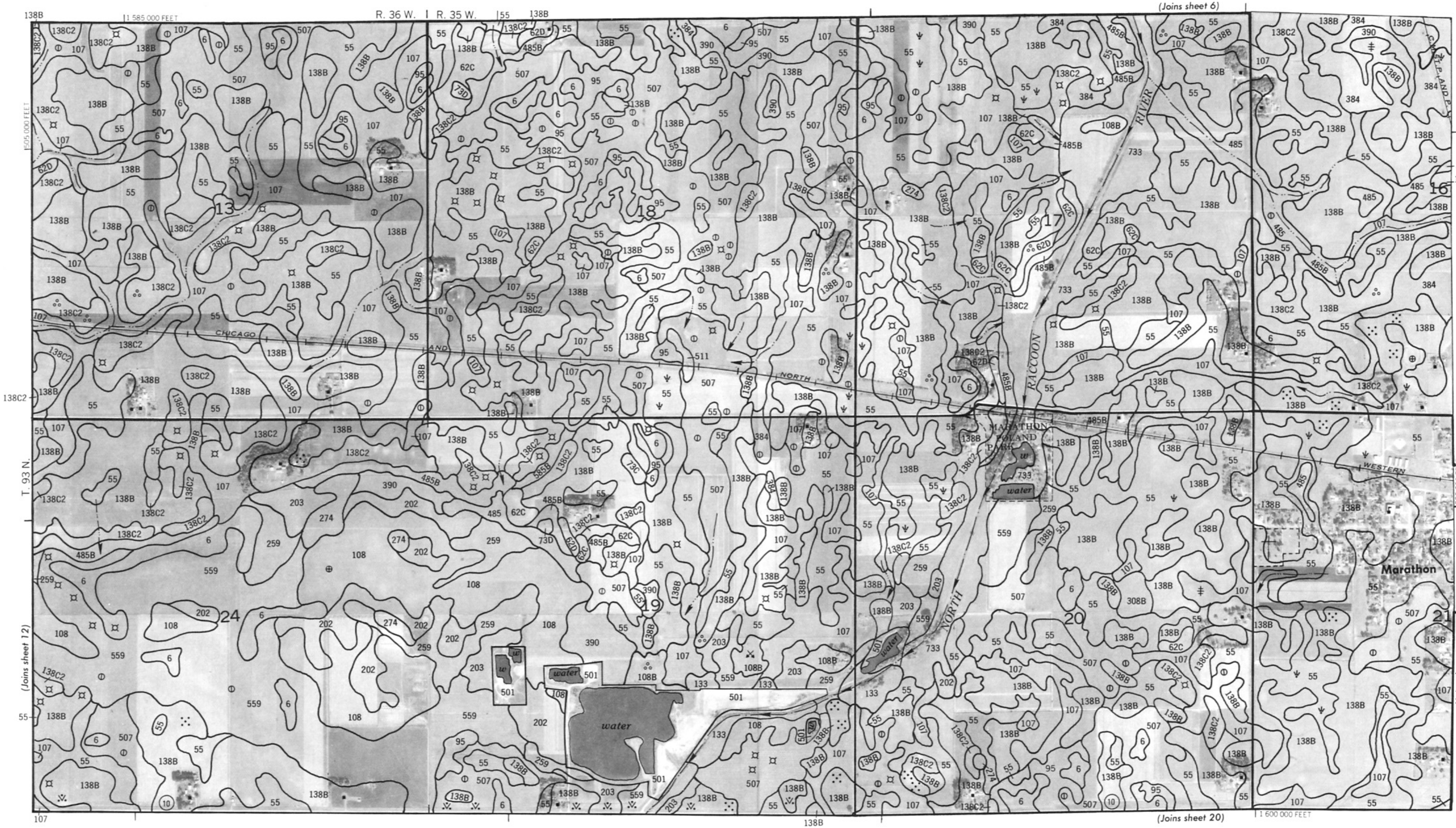



(Joins sheet 4)
(Joins sheet 10)
(Joins sheet 12)
(Joins sheet 18)
R. 37 W. | R. 36 W.
T. 93 N.
1 550 000 FEET
1 565 000 FEET
505 000 FEET
500 000 FEET
CHICAGO AND NORTH WESTERN
Soldier Creek
BORROW PIT
71
10
13
14
17
18
19
20
23
24
N

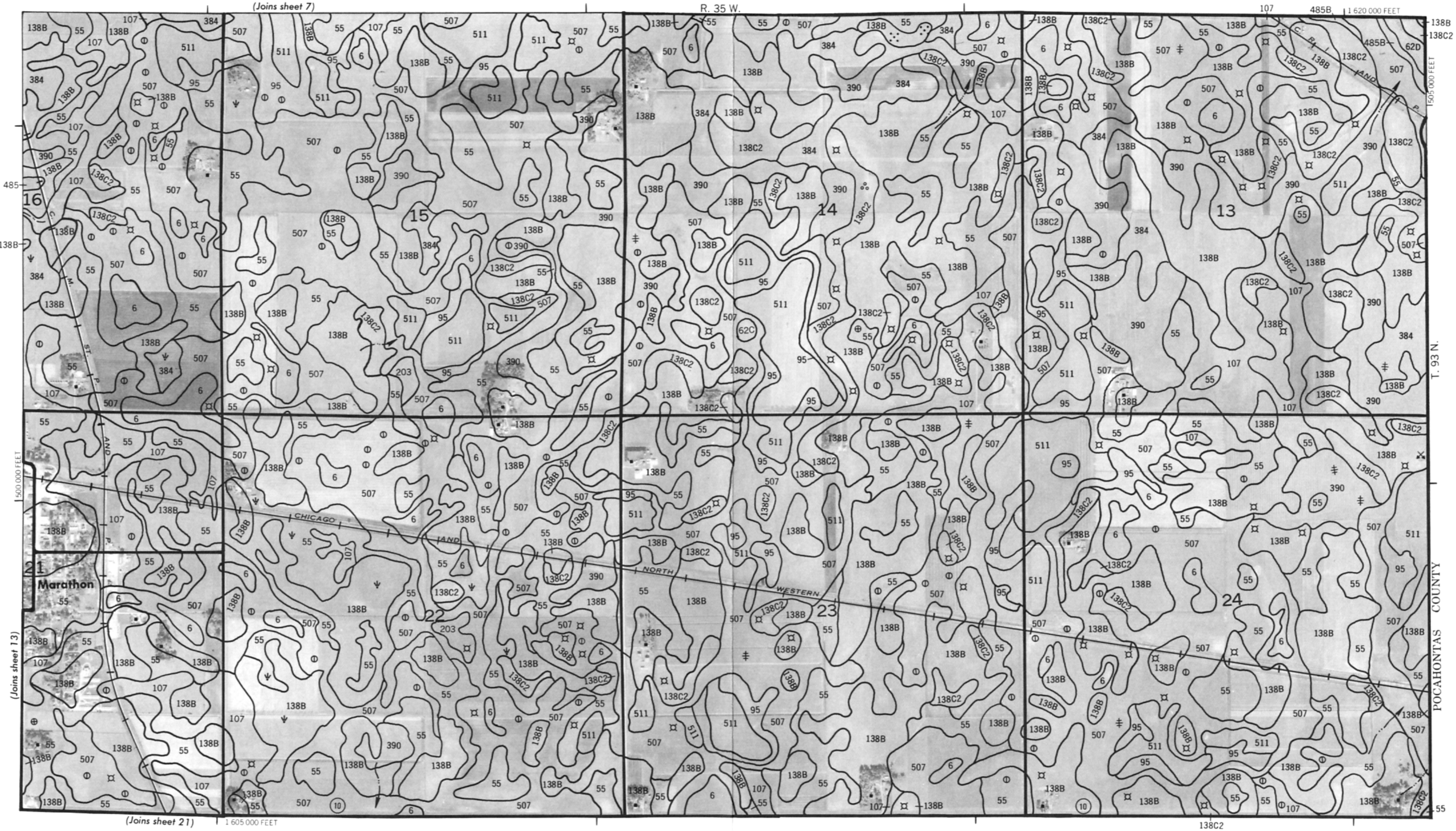
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 12

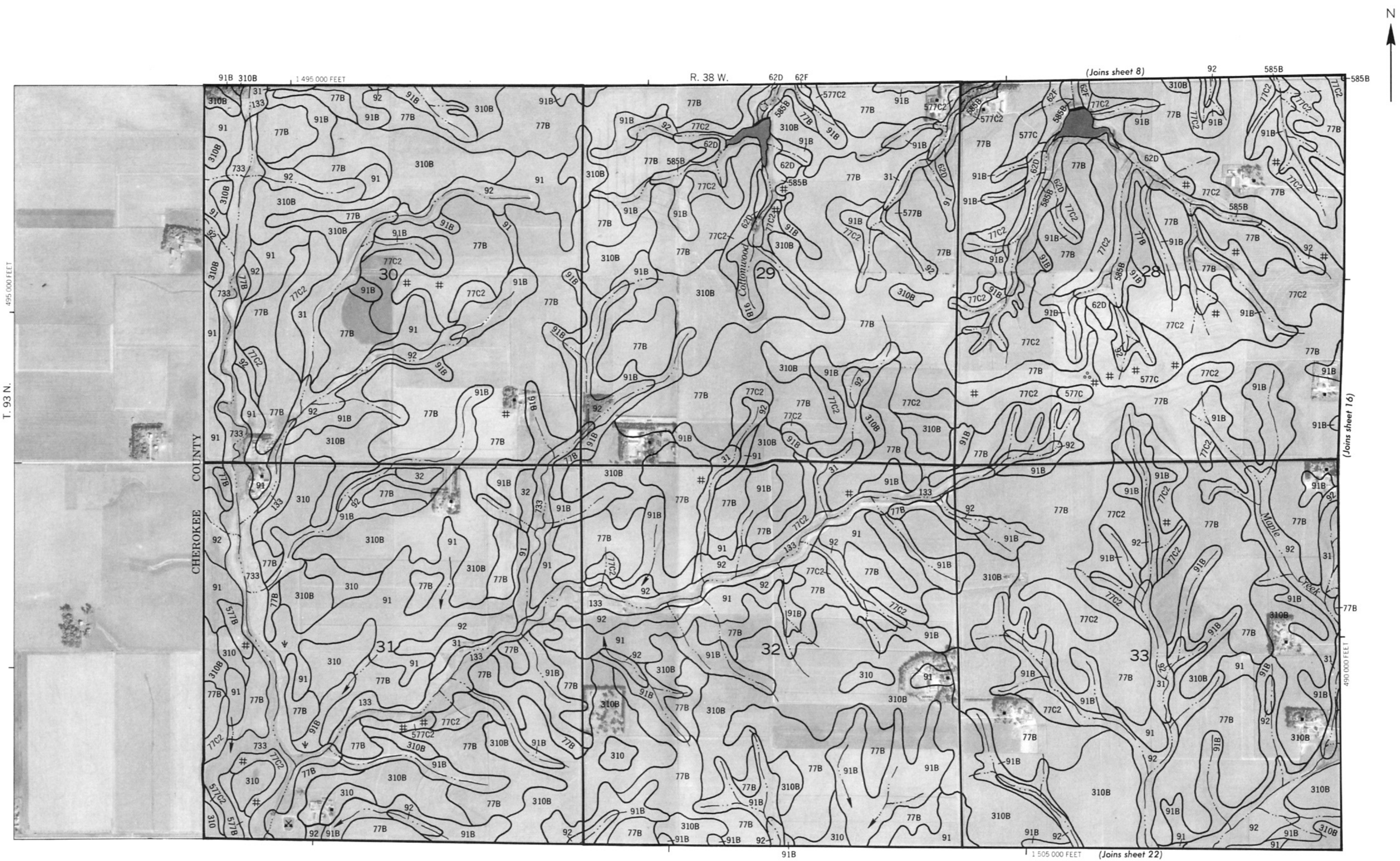


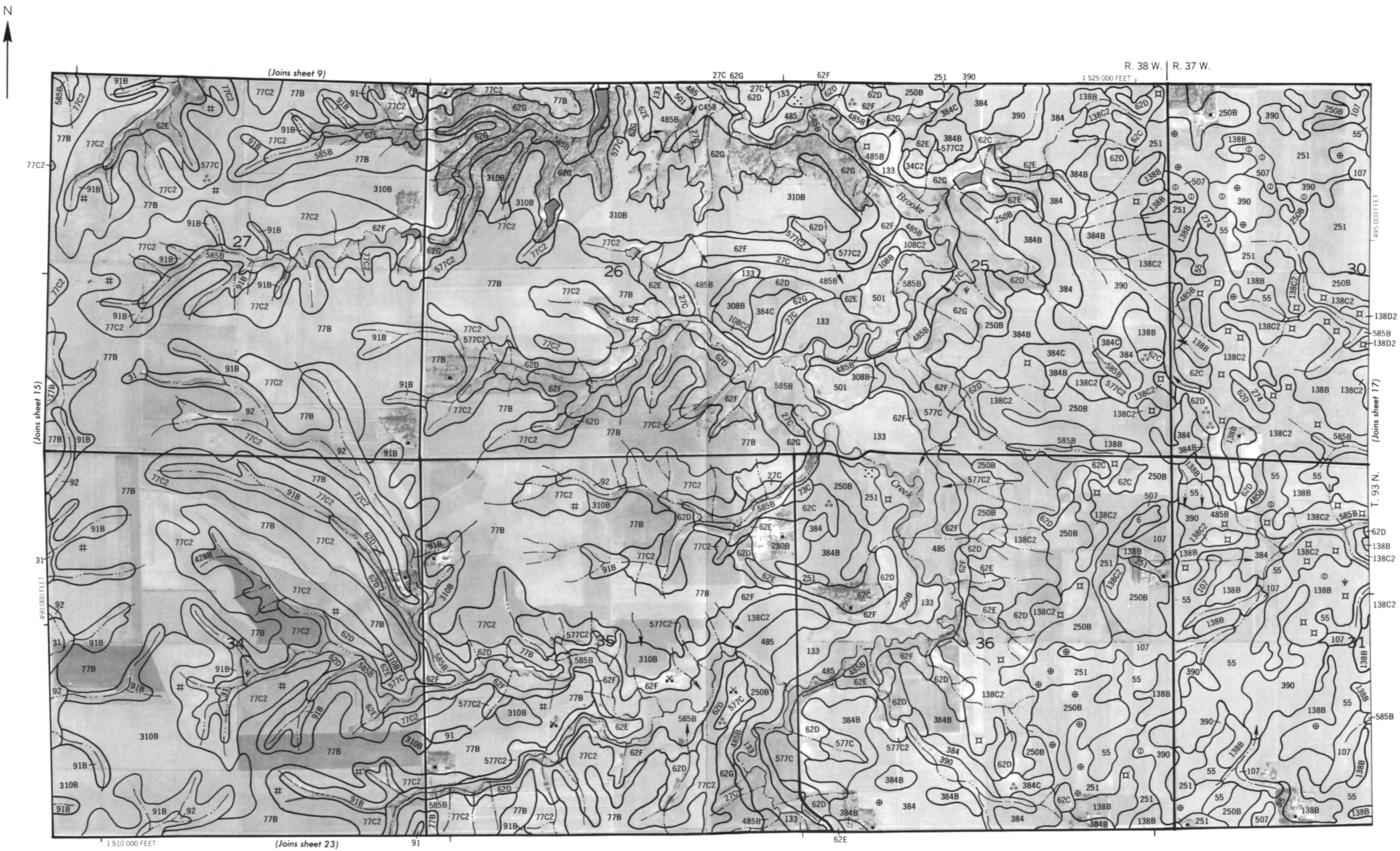
N


(Joins sheet 6)
(Joins sheet 12)
(Joins sheet 14)
(Joins sheet 20)
R. 36 W.
R. 35 W.
T. 93 N.
1 585 000 FEET
1 600 000 FEET
500 000 FEET
RACCOON
RIVER
NORTH
CHICAGO
AND
NORTH
WESTERN
MARATHON
POLAND
PARK
Marathon
water
13
16
17
18
19
20
21
24

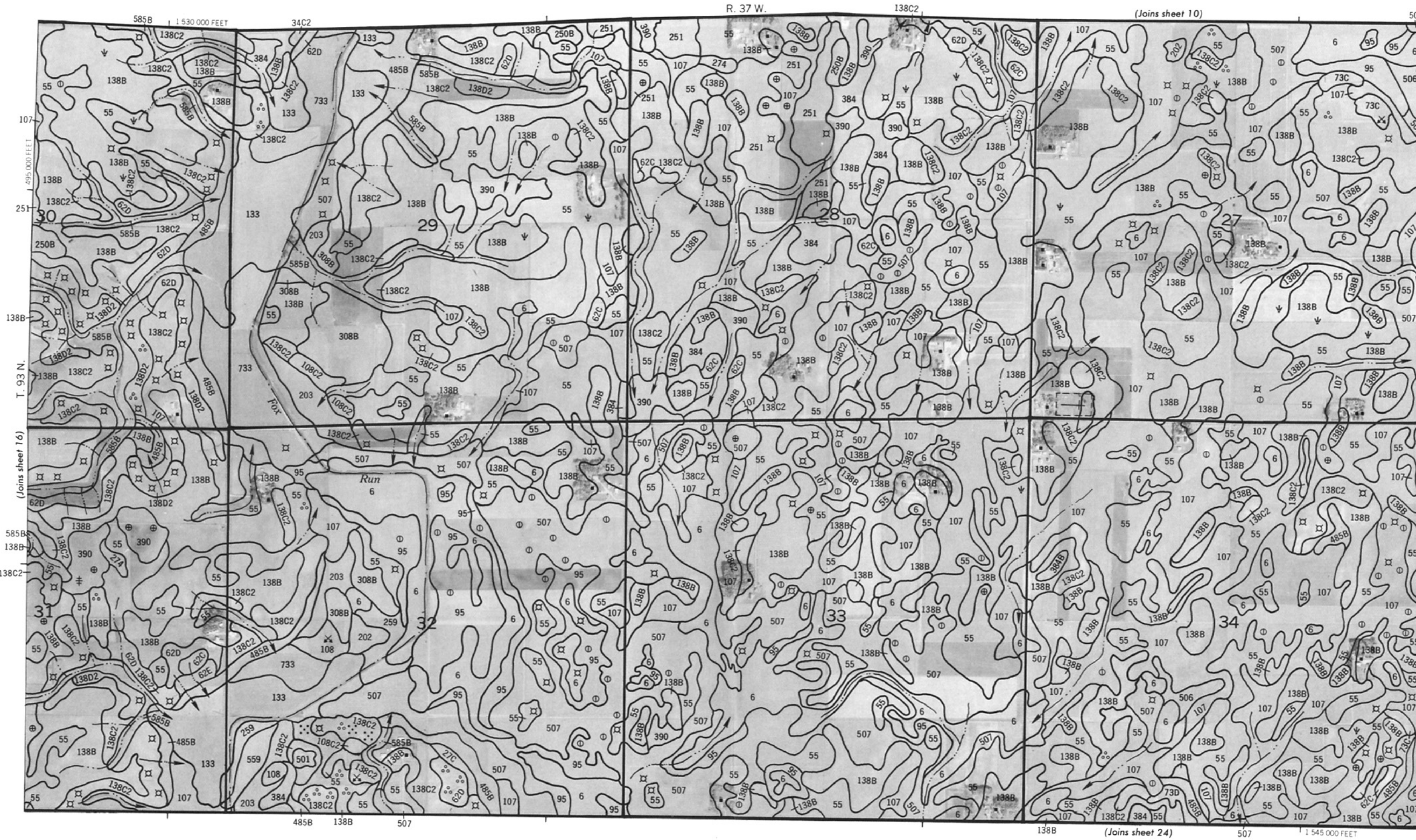
N


(Joins sheet 7)
R. 35 W.
1 620 000 FEET
1 505 000 FEET
T. 93 N.
POCAHONTAS COUNTY
500 000 FEET
(Joins sheet 13)
(Joins sheet 21)
1 605 000 FEET
Marathon
CHICAGO AND NORTH WESTERN
16
15
14
13
21
22
23
24


N
(Joins sheet 8)
(Joins sheet 16)
(Joins sheet 22)
R. 38 W.
T. 93 N.
CHEROKEE COUNTY
1 495 000 FEET
1 505 000 FEET
495 000 FEET
490 000 FEET
28
29
30
31
32
33
Cottonwood
Maple Creek

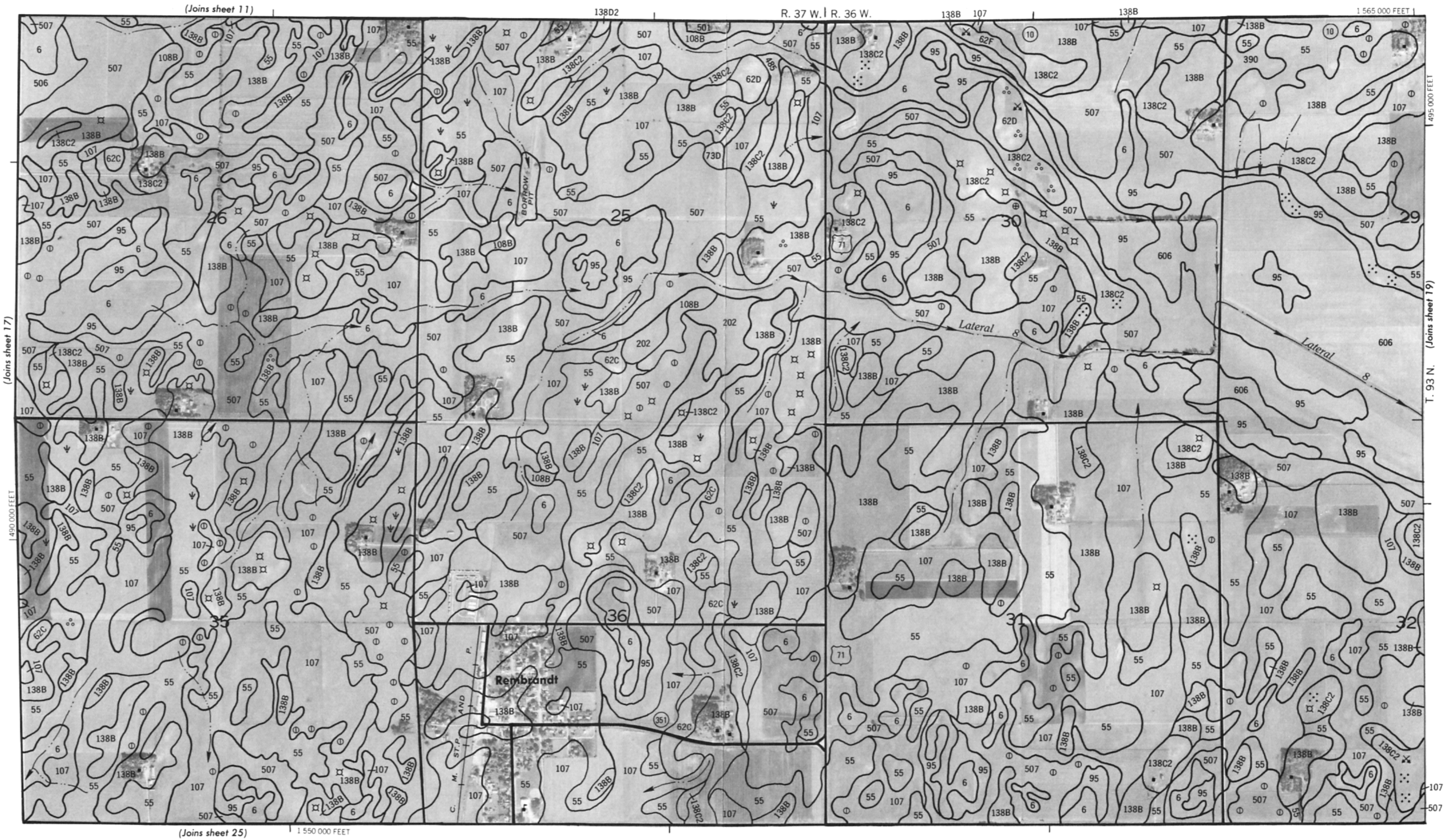

N
(Joins sheet 9)
(Joins sheet 15)
(Joins sheet 17)
(Joins sheet 23)
R. 38 W.
R. 37 W.
T. 93 N.
1 525 000 FEET
1 510 000 FEET
495 000 FEET
490 000 FEET
27
26
25
30
34
35
36
31
Brooke
Creek

N


R. 37 W.
(Joins sheet 10)
(Joins sheet 18)
(Joins sheet 24)
(Joins sheet 16)
T. 93 N.
1 530 000 FEET
1 545 000 FEET
495 000 FEET
490 000 FEET
Fox
Run
30
29
28
27
31
32
33
34

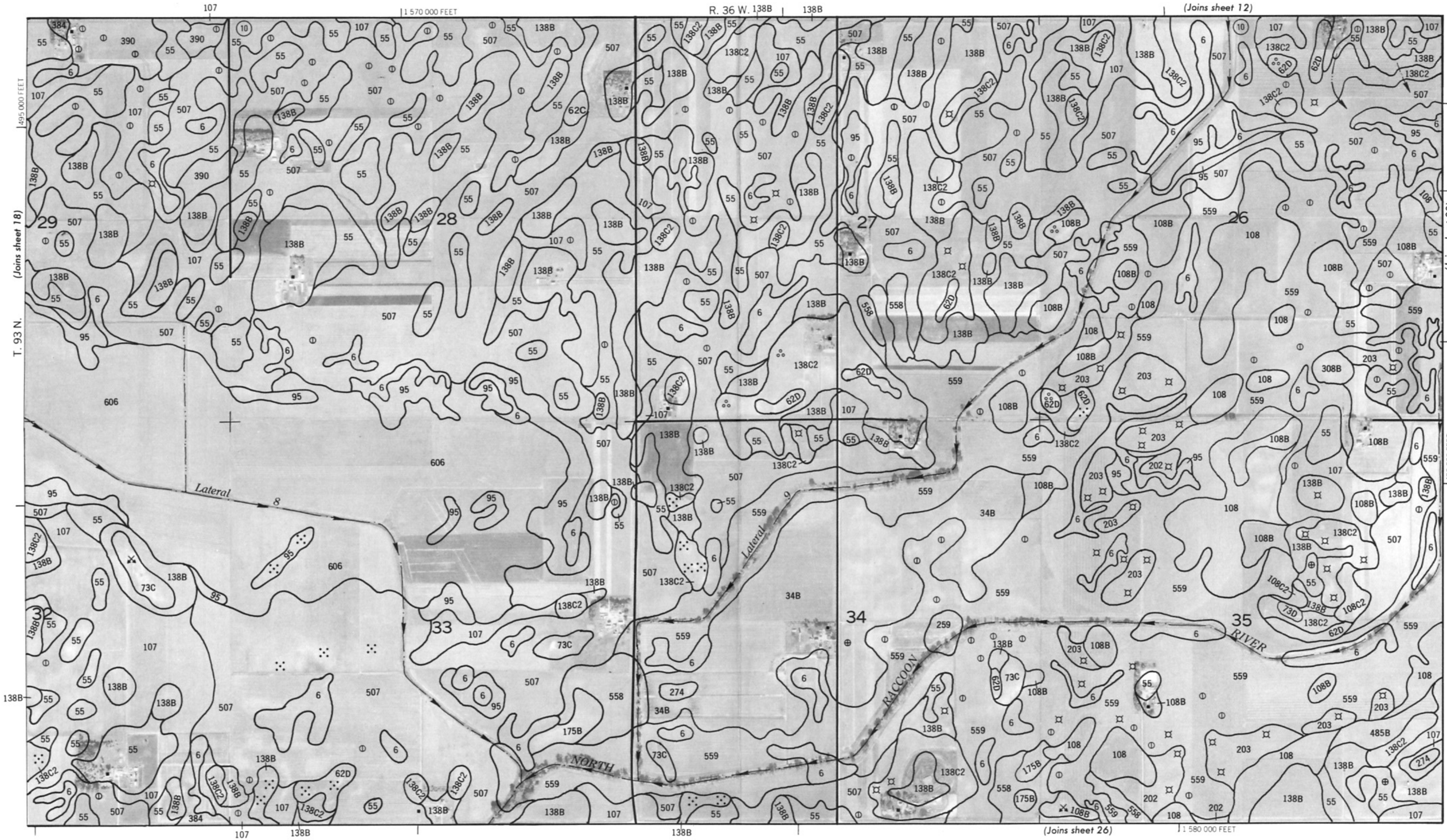
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 18

N

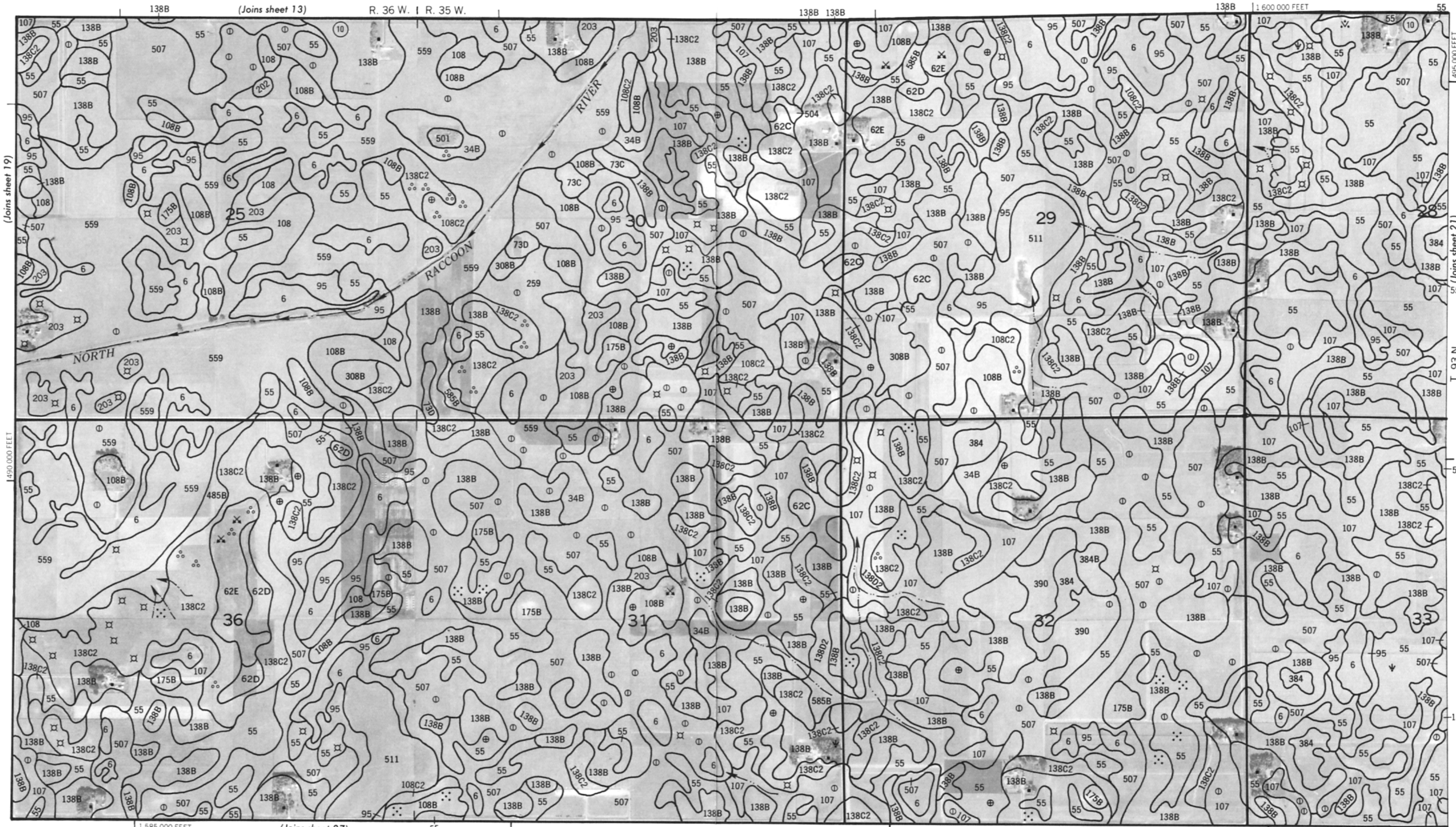


19

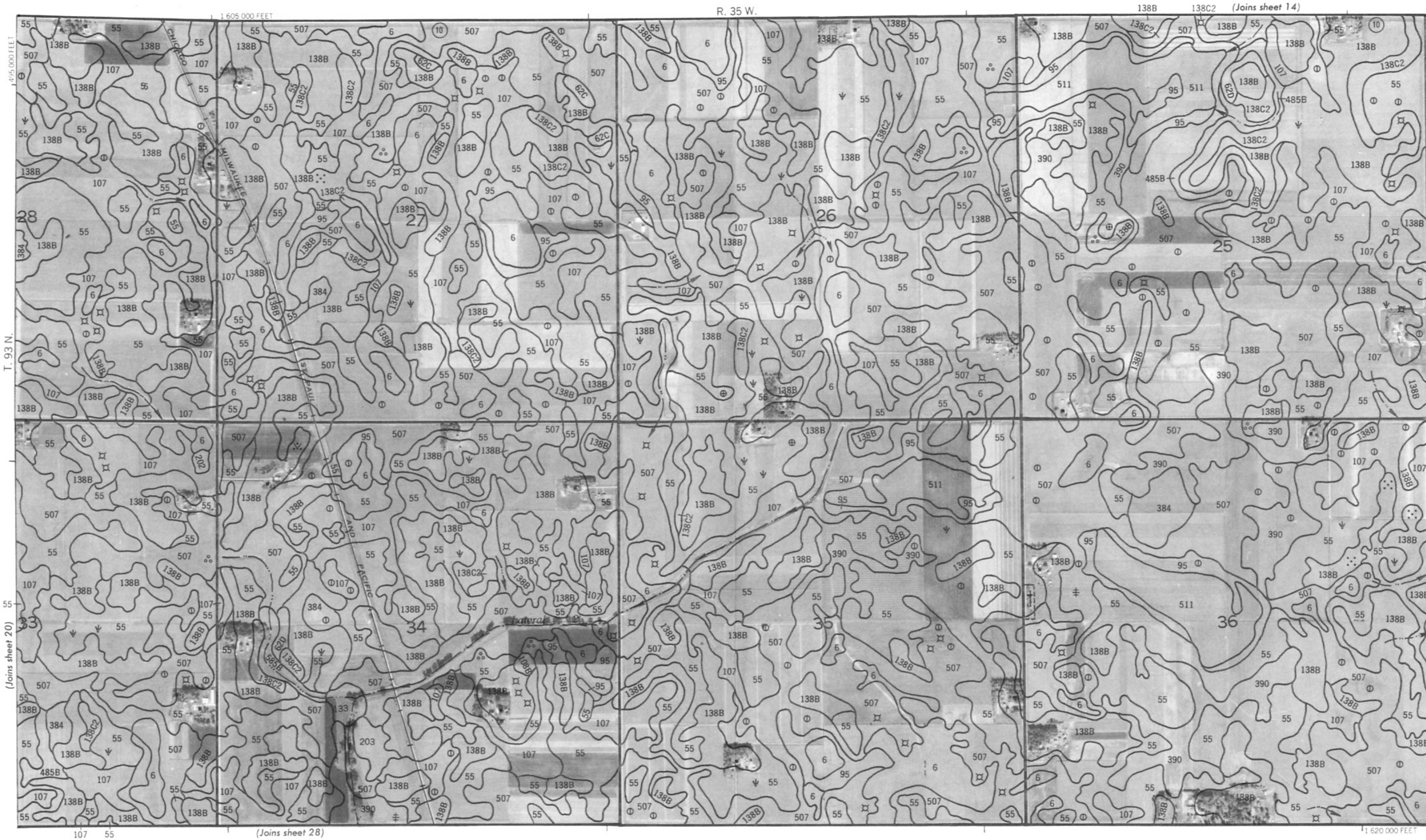
N


(Joins sheet 12)
(Joins sheet 18)
(Joins sheet 20)
(Joins sheet 26)
R. 36 W.
T. 93 N.
1 570 000 FEET
1 580 000 FEET
495 000 FEET
490 000 FEET
29
28
27
26
32
33
34
35
Lateral 8
Lateral 9
NORTH
RACCOON
RIVER

N


(Joins sheet 13)
R. 36 W. | R. 35 W.
1 600 000 FEET
495 000 FEET
(Joins sheet 19)
(Joins sheet 21)
T. 93 N.
490 000 FEET
1 585 000 FEET
(Joins sheet 27)
NORTH RACCOON RIVER
25
30
29
28
36
31
32
33

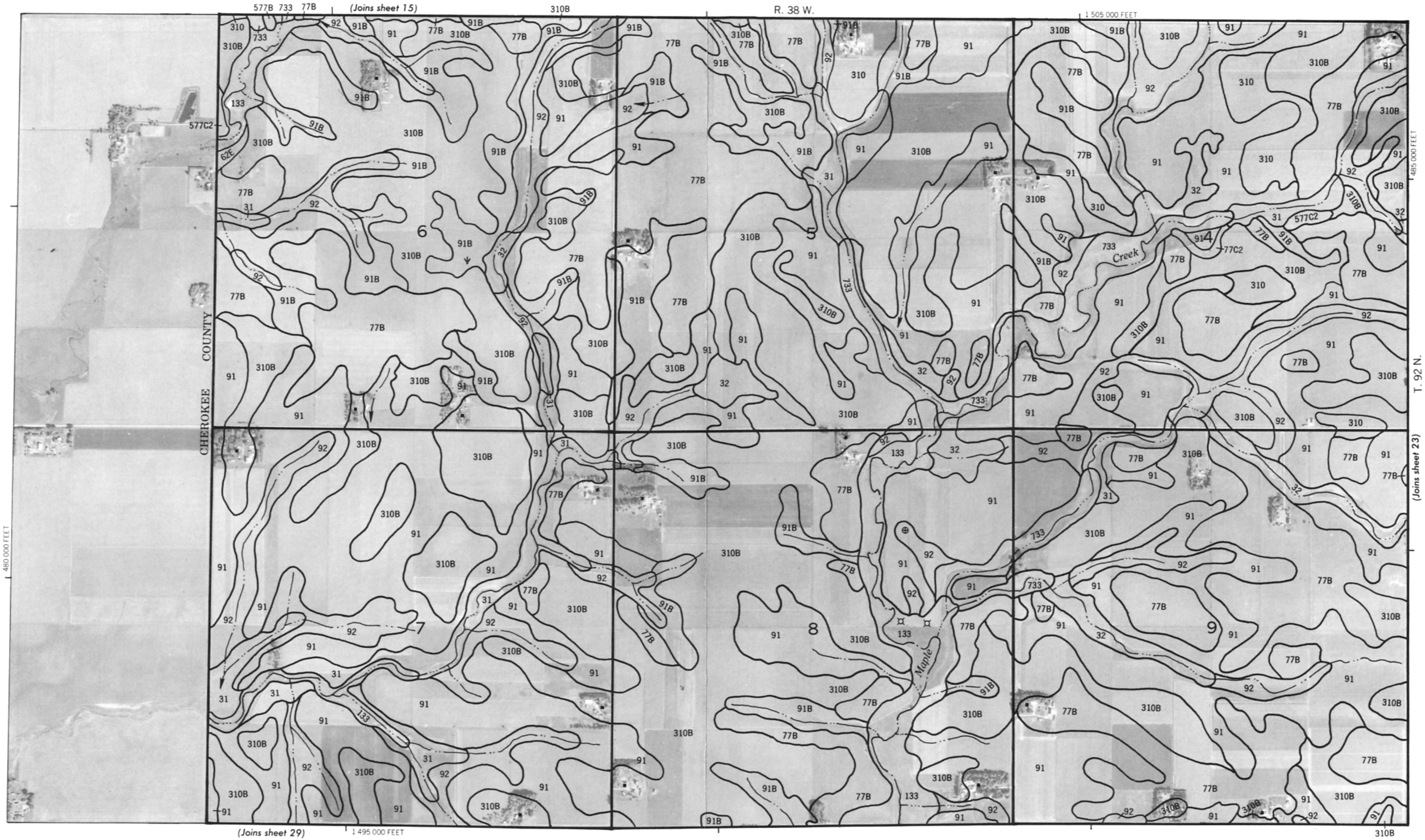
N



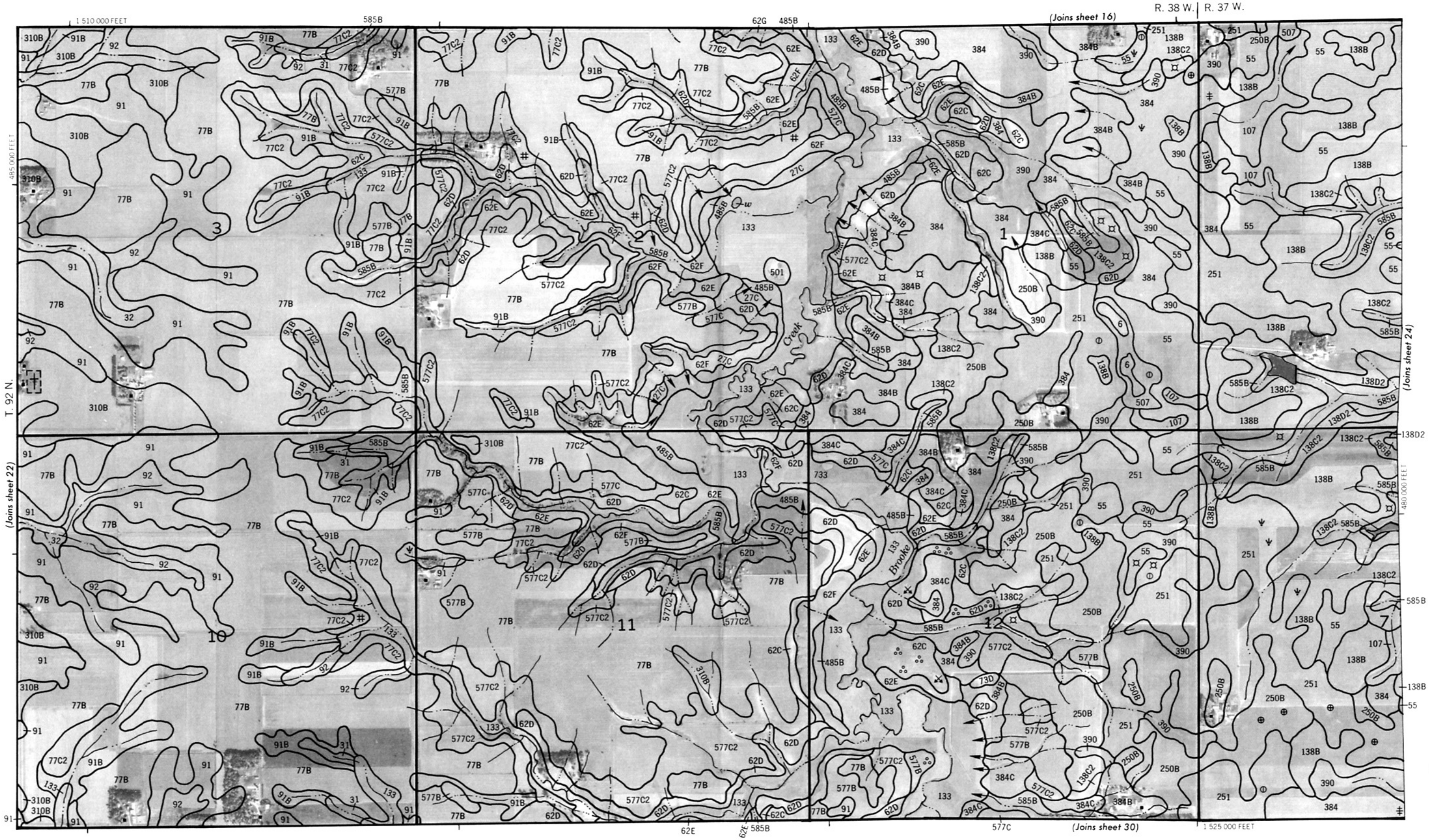
R. 35 W.
(Joins sheet 14)
1 605 000 FEET
495 000 FEET
T. 93 N.
(Joins sheet 20)
(Joins sheet 28)
POCAHONTAS COUNTY
1 620 000 FEET
485 000 FEET
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
Lateral
28
27
26
25
33
34
35
36

N

BUENA VISTA COUNTY, IOWA — SHEET NUMBER 22

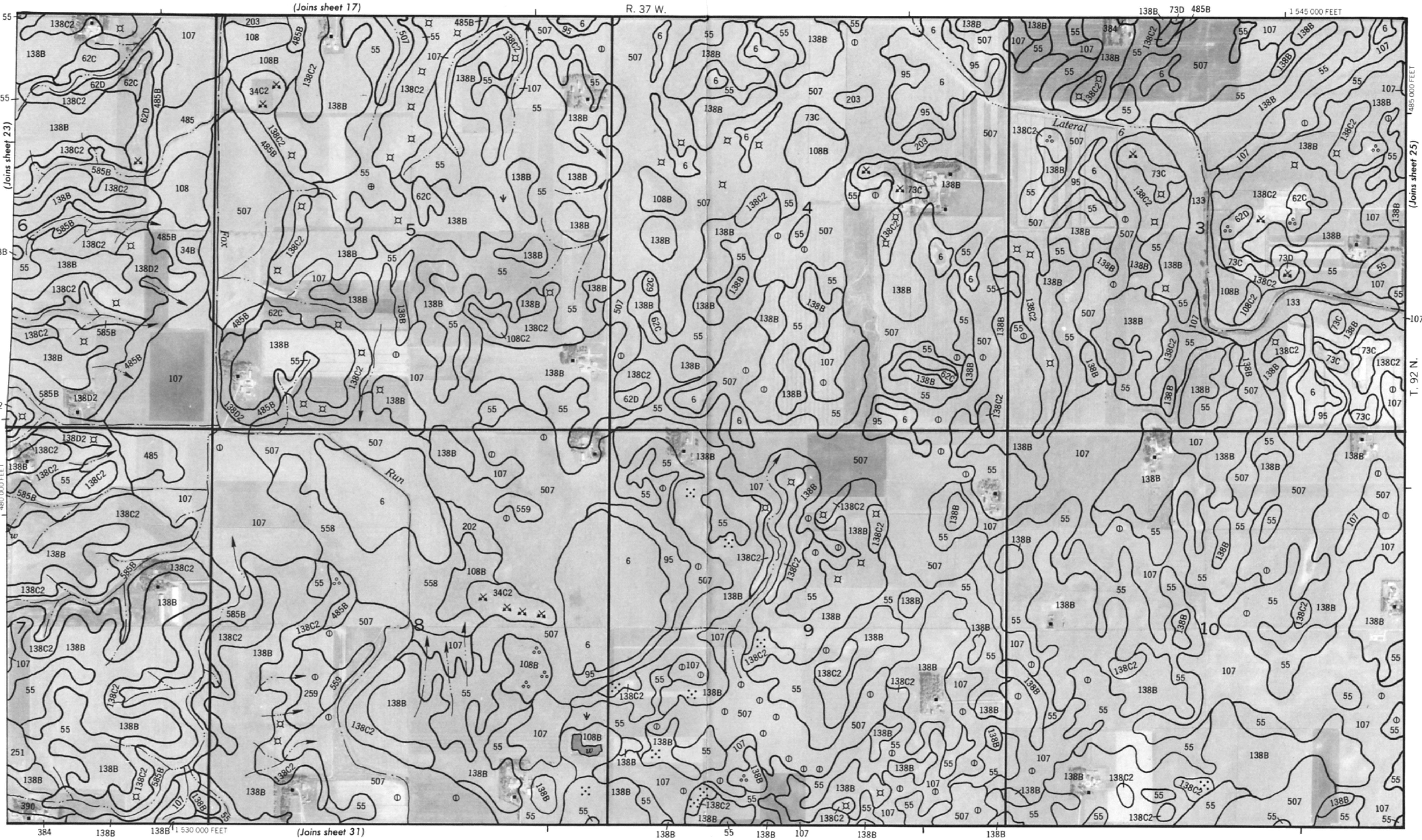


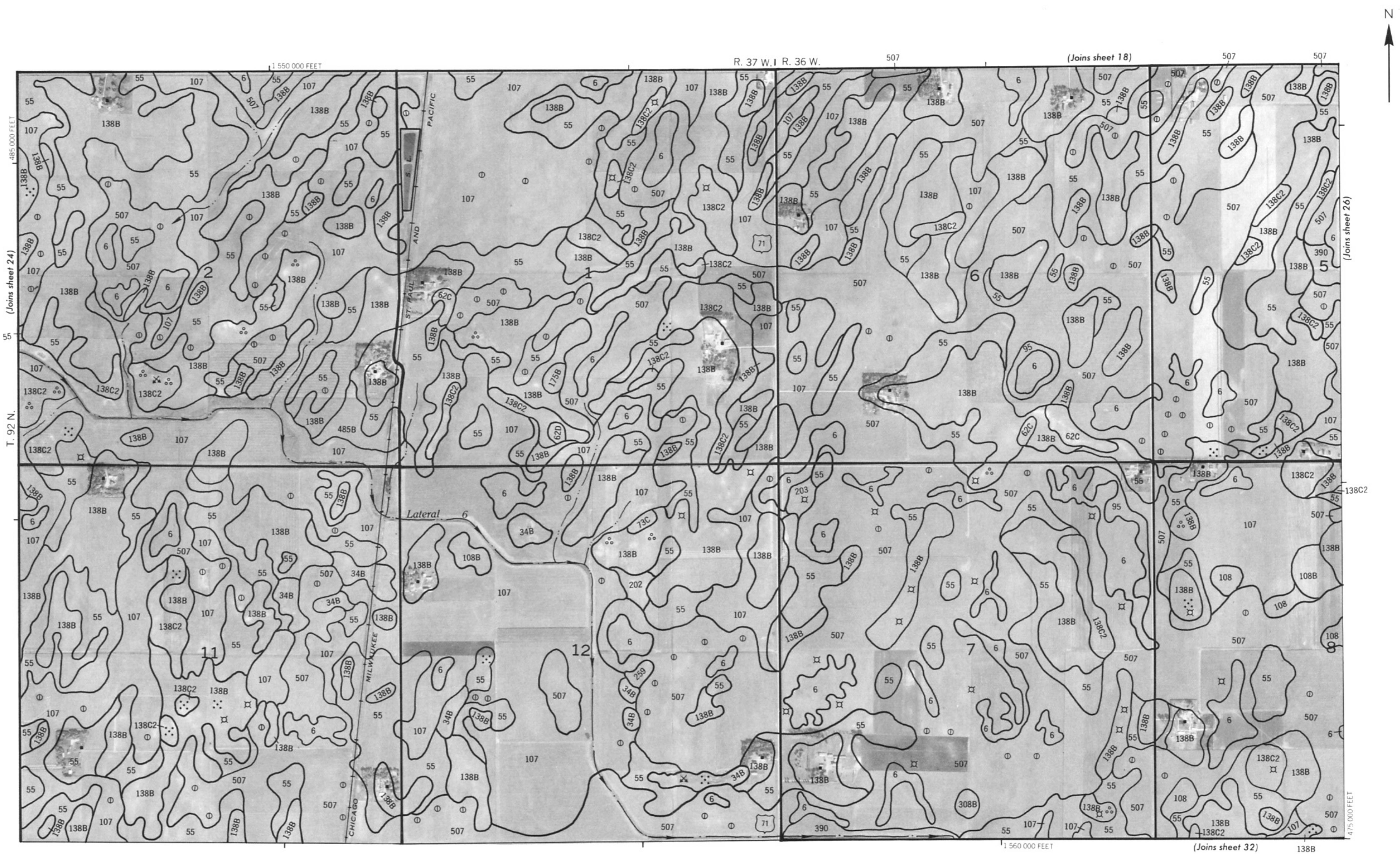
N

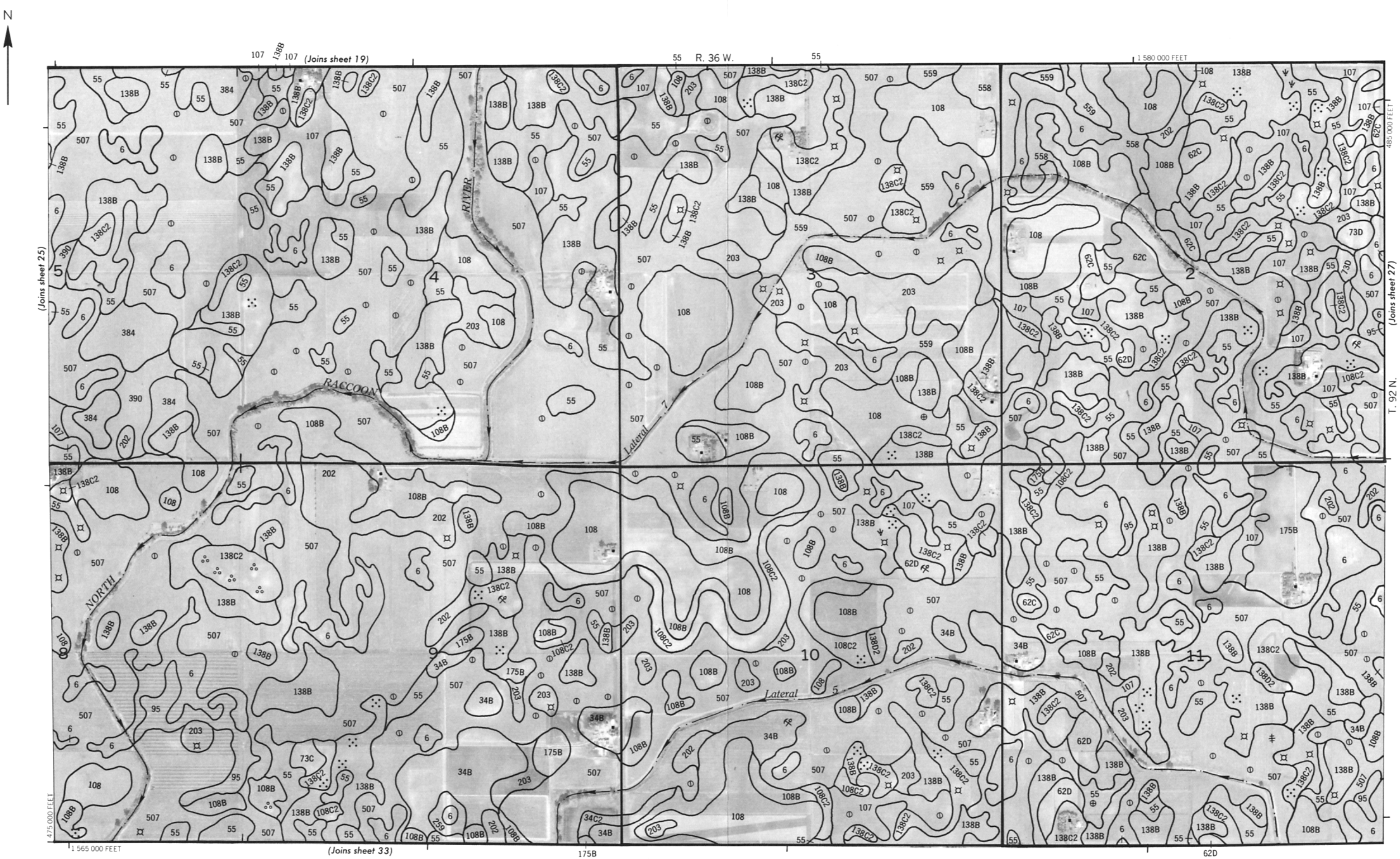

1 510 000 FEET
R. 38 W.
R. 37 W.
(Joins sheet 16)
(Joins sheet 22)
(Joins sheet 24)
(Joins sheet 30)
T. 92 N.
485 000 FEET
480 000 FEET
1 525 000 FEET
Creek
Brooke
1
2
3
6
7
10
11
12

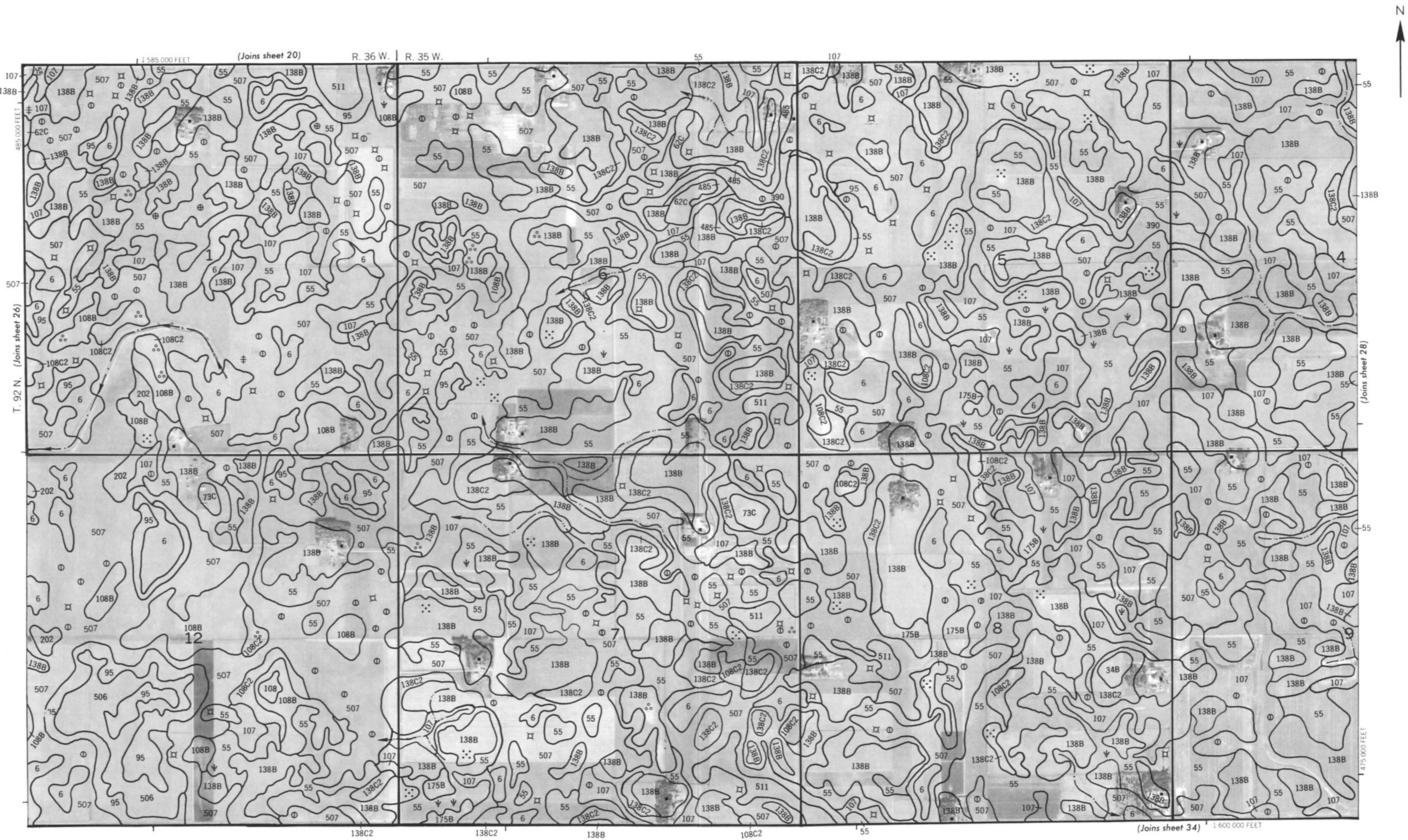
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 24

N

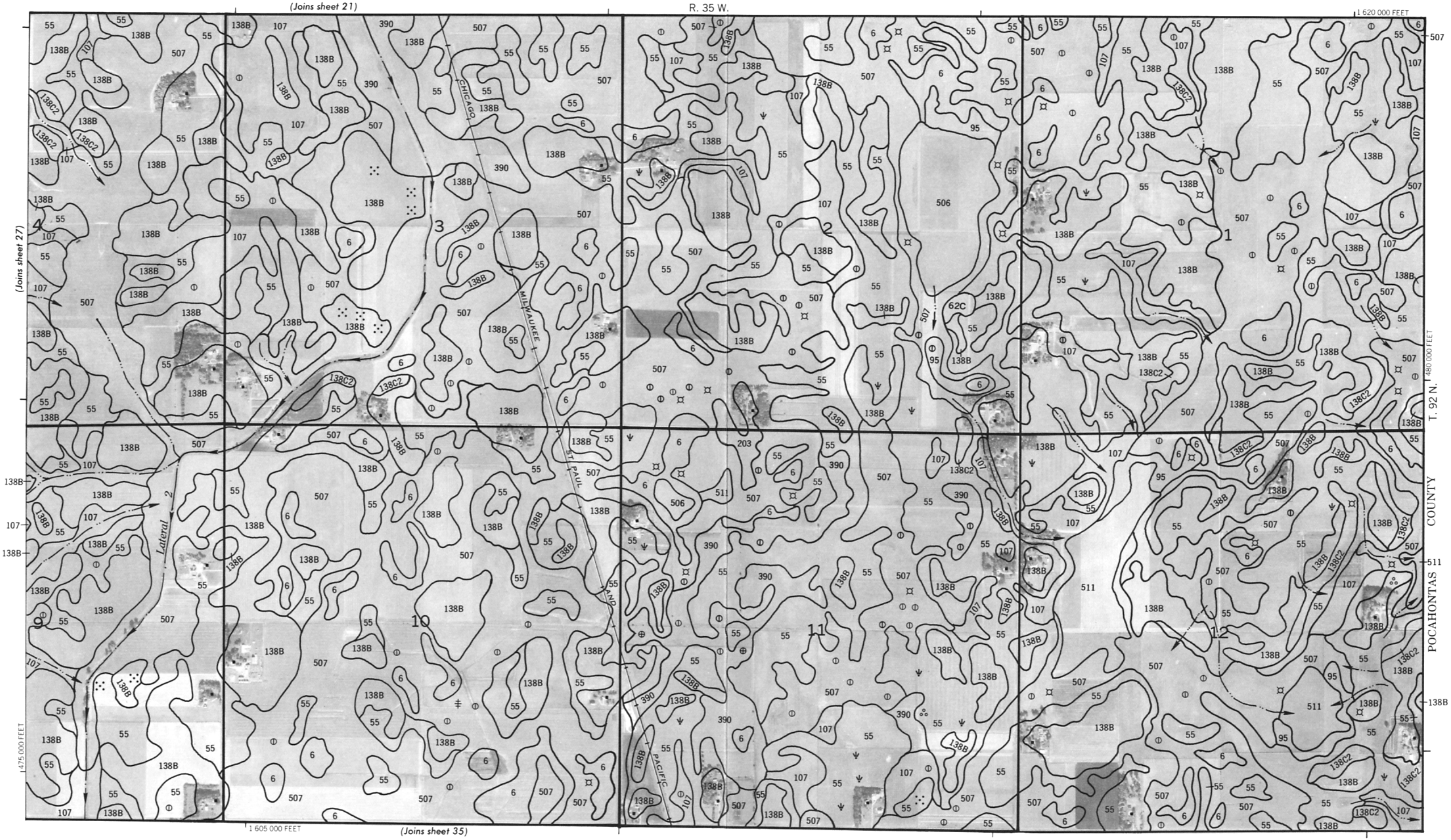


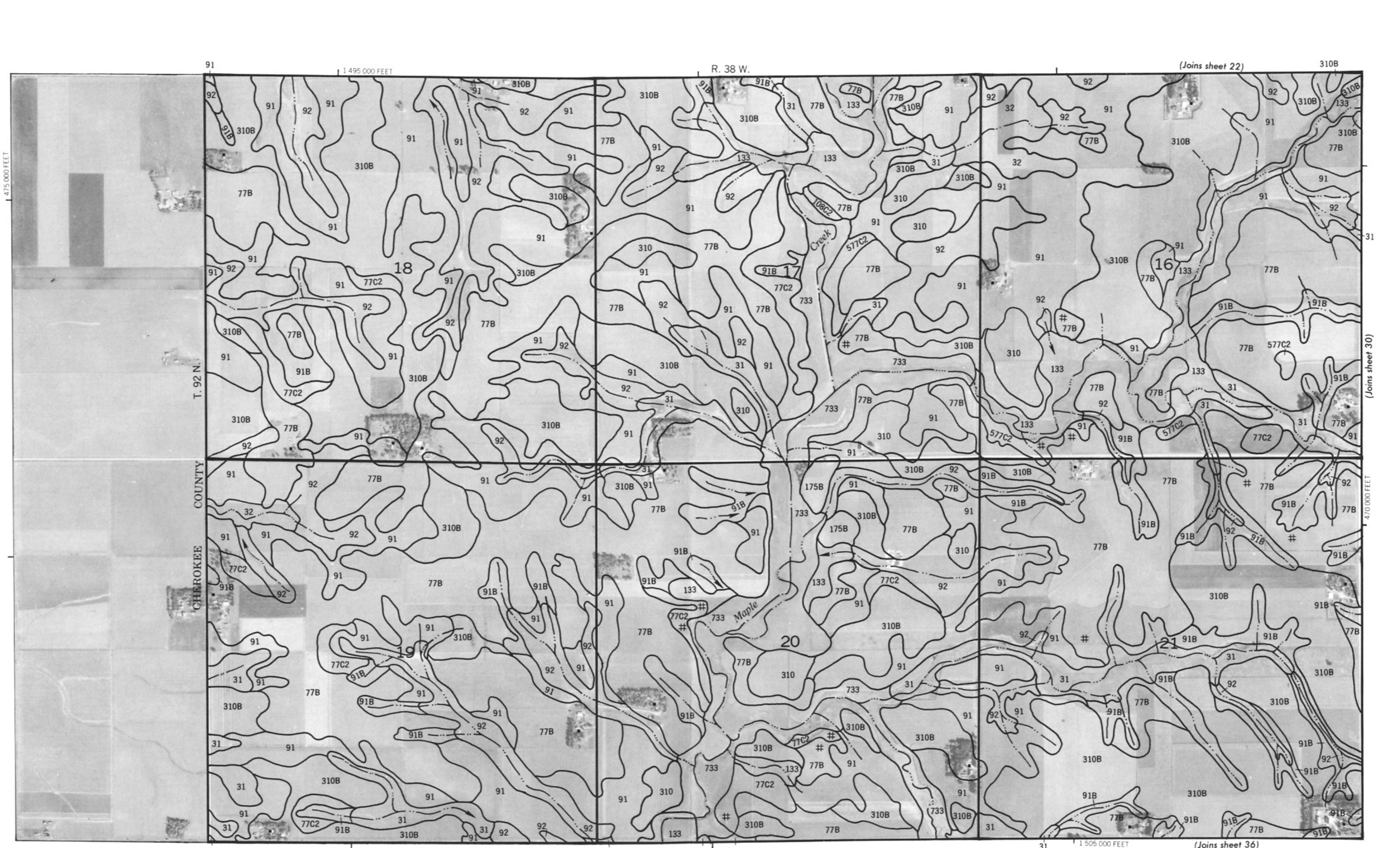

N
(Joins sheet 18)
(Joins sheet 24)
(Joins sheet 26)
(Joins sheet 32)
R. 37 W.
R. 36 W.
T. 92 N.
1 550 000 FEET
1 560 000 FEET
485 000 FEET
475 000 FEET
Lateral 6
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
71
1
2
5
6
7
8
11
12

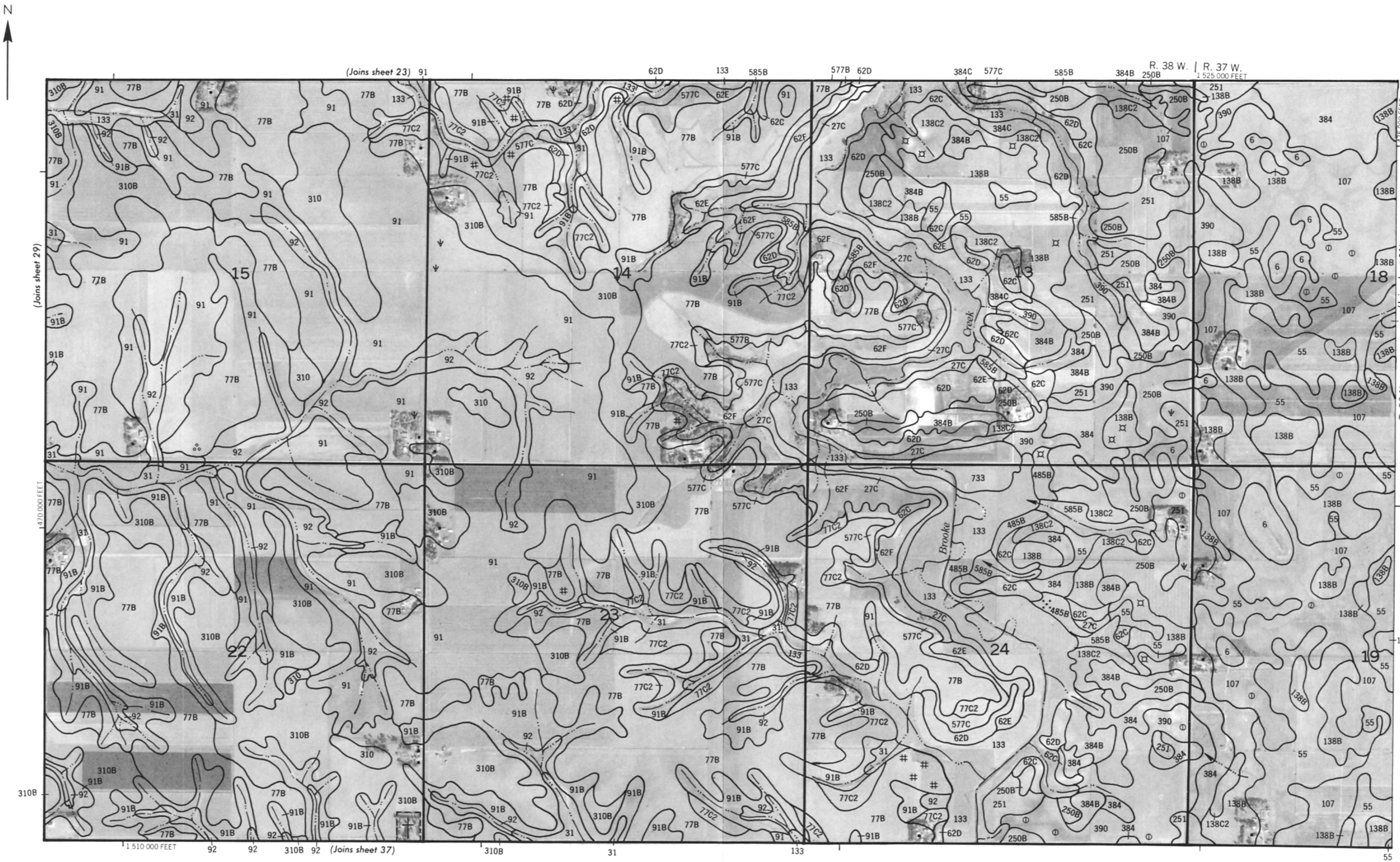

N
(Joins sheet 19)
R. 36 W.
1 580 000 FEET
485 000 FEET
(Joins sheet 25)
(Joins sheet 27)
T. 92 N.
RACCOON
RIVER
NORTH
Lateral 7
Lateral 5
475 000 FEET
1 565 000 FEET
(Joins sheet 33)
4
3
2
5
9
10
11


N
(Joins sheet 20)
R. 36 W.
R. 35 W.
1 585 000 FEET
485 000 FEET
(Joins sheet 26)
T. 92 N.
(Joins sheet 28)
475 000 FEET
(Joins sheet 34)
1 600 000 FEET
1
4
5
6
7
8
9
12

N

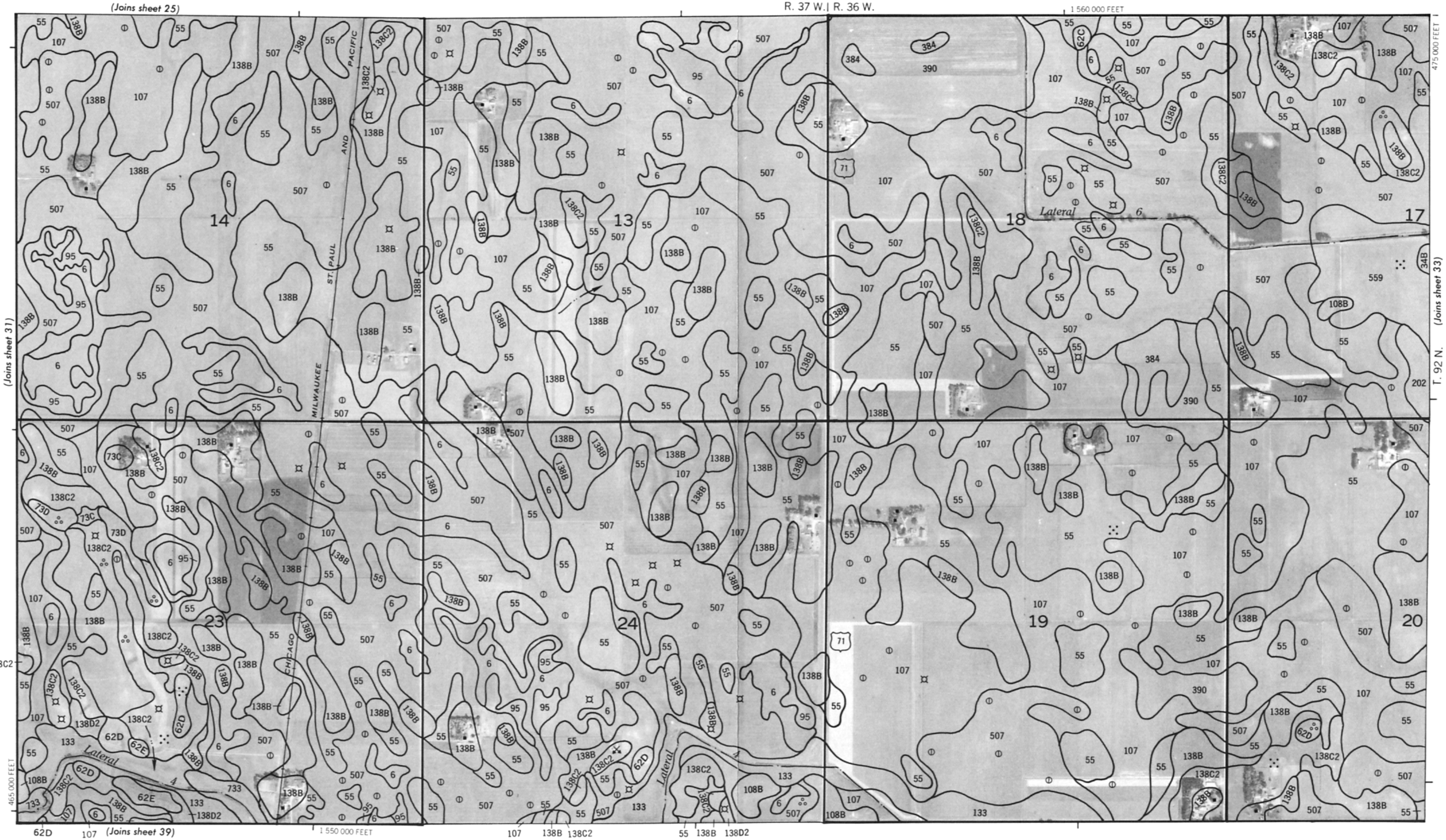

(Joins sheet 21)
R. 35 W.
1 620 000 FEET
507
480 000 FEET
T. 92 N.
POCAHONTAS COUNTY
511
138B
(Joins sheet 27)
138B
107
138B
475 000 FEET
1 605 000 FEET
(Joins sheet 35)
CHICAGO
MILWAUKEE
ST PAUL
AND
PACIFIC
Lateral 2


N
(Joins sheet 22)
R. 38 W.
1 495 000 FEET
475 000 FEET
T. 92 N.
CHEROKEE COUNTY
(Joins sheet 30)
470 000 FEET
1 505 000 FEET
(Joins sheet 36)
18
17
16
19
20
21
Creek
Maple

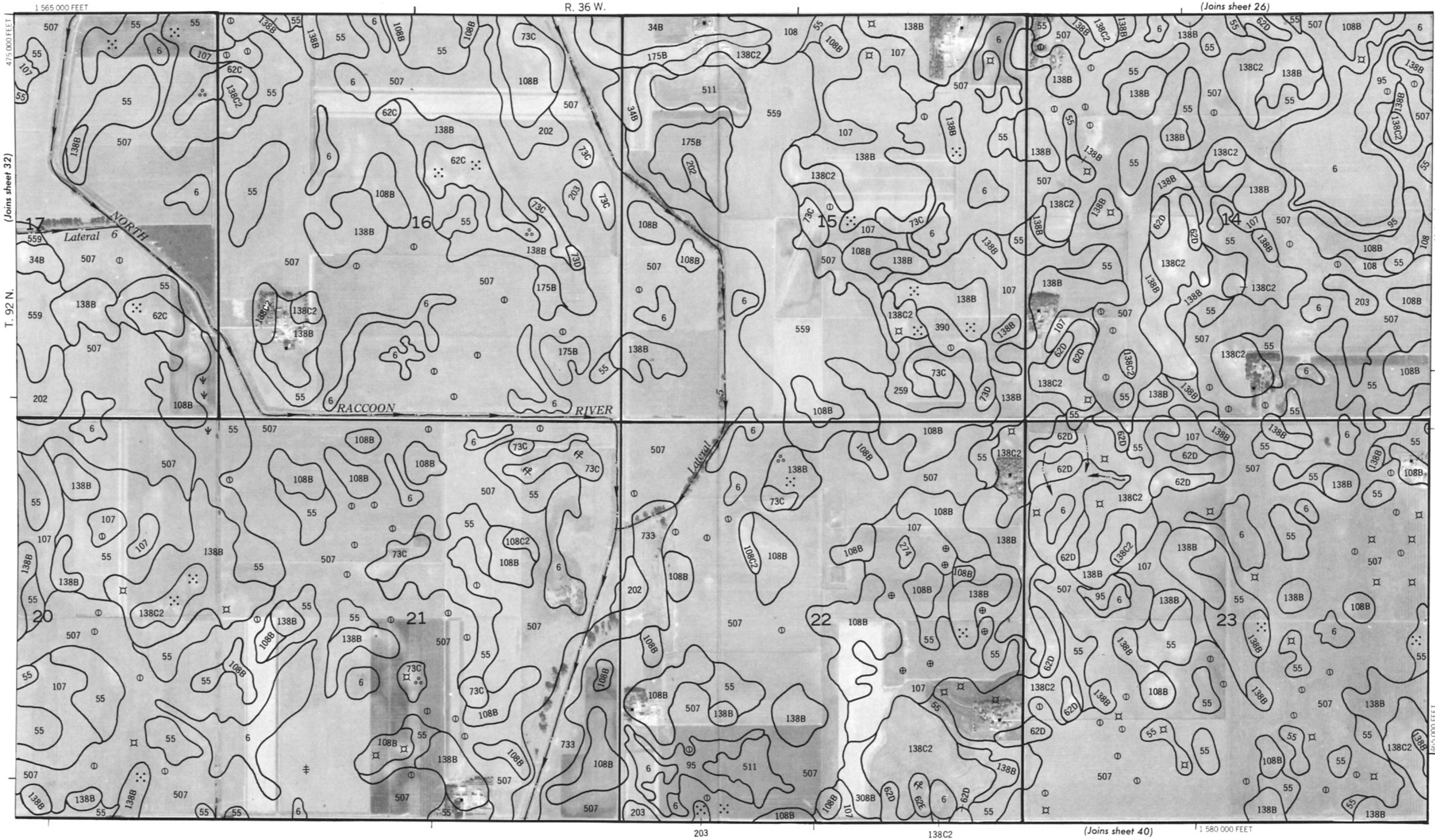

N
(Joins sheet 23)
(Joins sheet 29)
(Joins sheet 31)
(Joins sheet 37)
R. 38 W.
R. 37 W.
T. 92 N.
1 525 000 FEET
1 475 000 FEET
1 470 000 FEET
1 510 000 FEET
15
14
13
18
22
23
24
19
Creek
Brooke


N
1 530 000 FEET
R. 37 W.
(Joins sheet 24)
475 000 FEET
(Joins sheet 30)
T. 92 N.
(Joins sheet 32)
465 000 FEET
(Joins sheet 38)
1 545 000 FEET
18
17
16
15
19
20
21
22
Run
Fox
Lateral 4

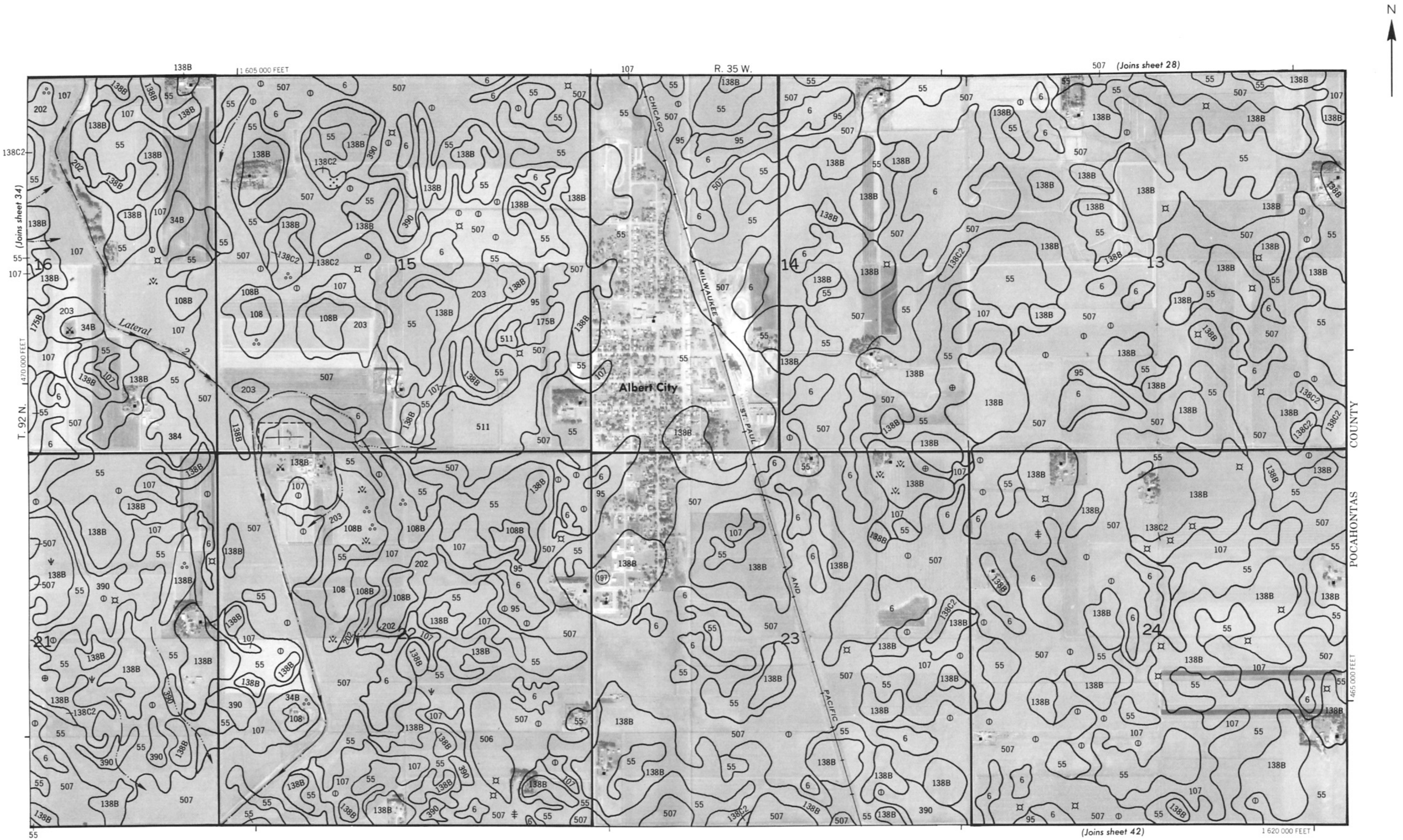
N


(Joins sheet 25)
R. 37 W. | R. 36 W.
1 560 000 FEET
475 000 FEET
(Joins sheet 31)
(Joins sheet 33)
T. 92 N.
465 000 FEET
1 550 000 FEET
(Joins sheet 39)
14
13
18
17
23
24
19
20
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
Lateral 6
Lateral 4
71

N

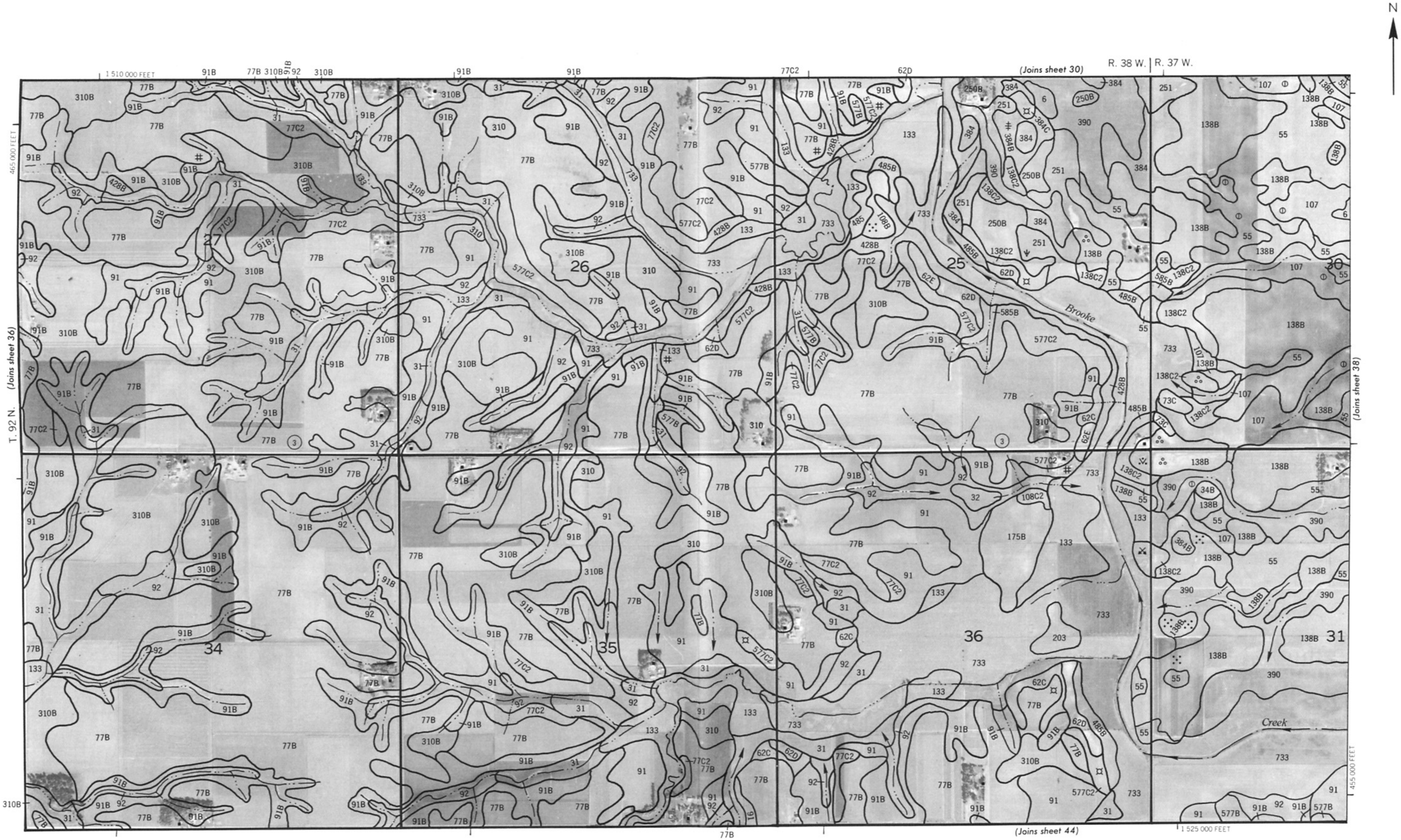

1 565 000 FEET
R. 36 W.
(Joins sheet 26)
475 000 FEET
(Joins sheet 32)
T. 92 N.
(Joins sheet 34)
465 000 FEET
(Joins sheet 40)
1 580 000 FEET
NORTH
Lateral 6
RACCOON
RIVER
Lateral 5
17
16
15
14
20
21
22
23

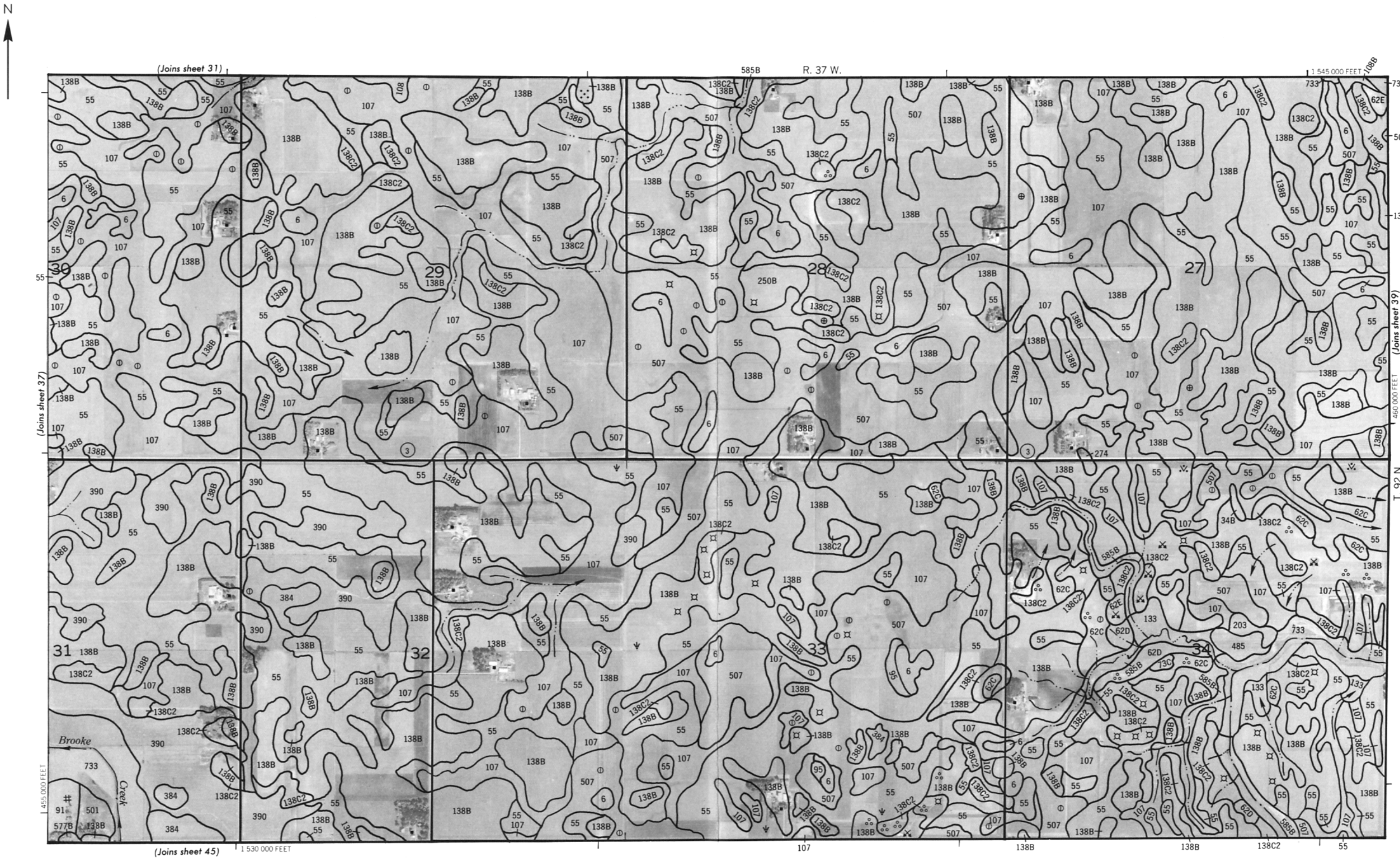
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 34

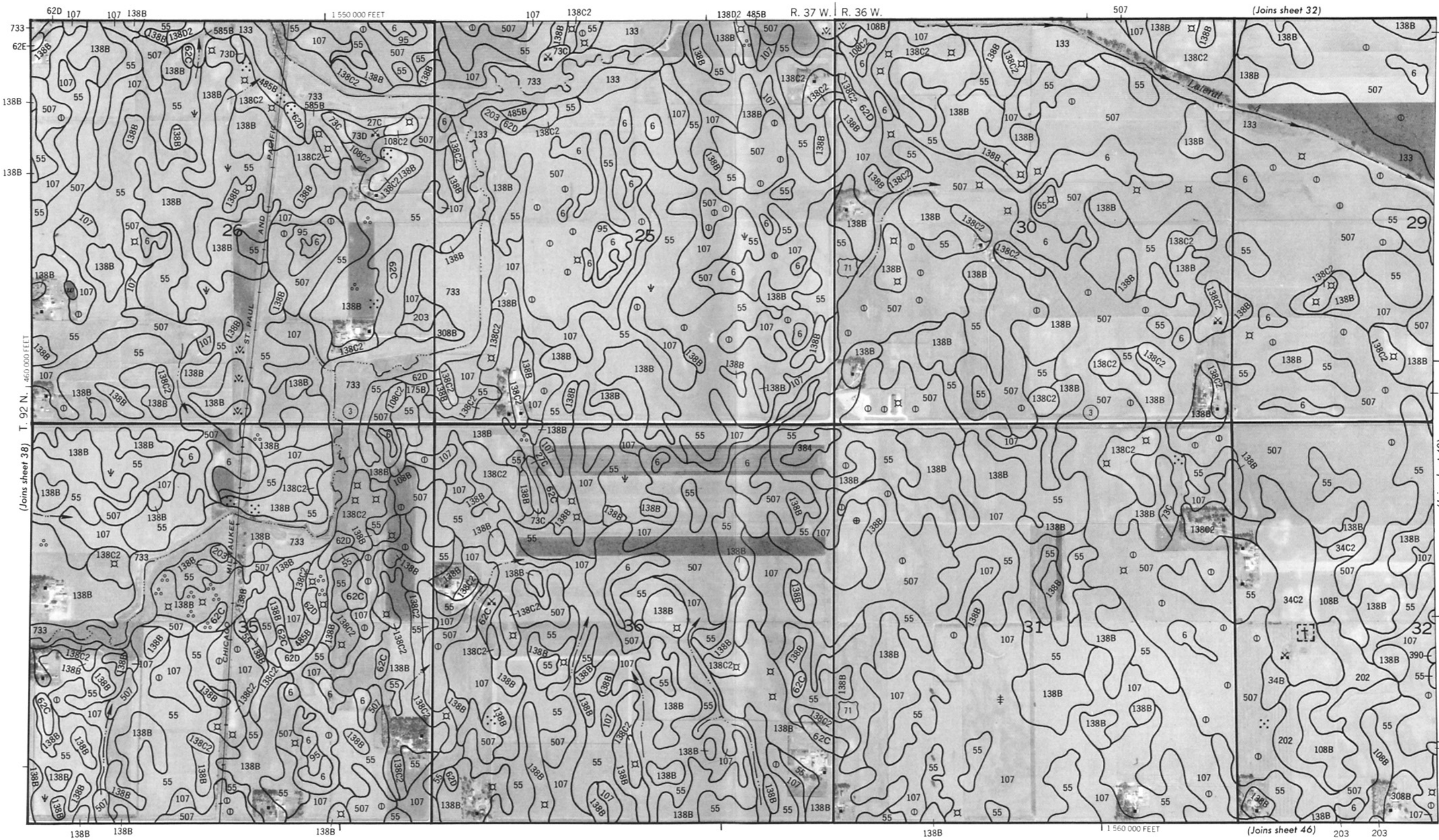

N
1 605 000 FEET
R. 35 W.
(Joins sheet 28)
(Joins sheet 34)
T. 92 N.
470 000 FEET
Lateral
2
Albert City
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
197
POCAHONTAS COUNTY
465 000 FEET
(Joins sheet 42)
1 620 000 FEET
16
15
14
13
21
22
23
24

N

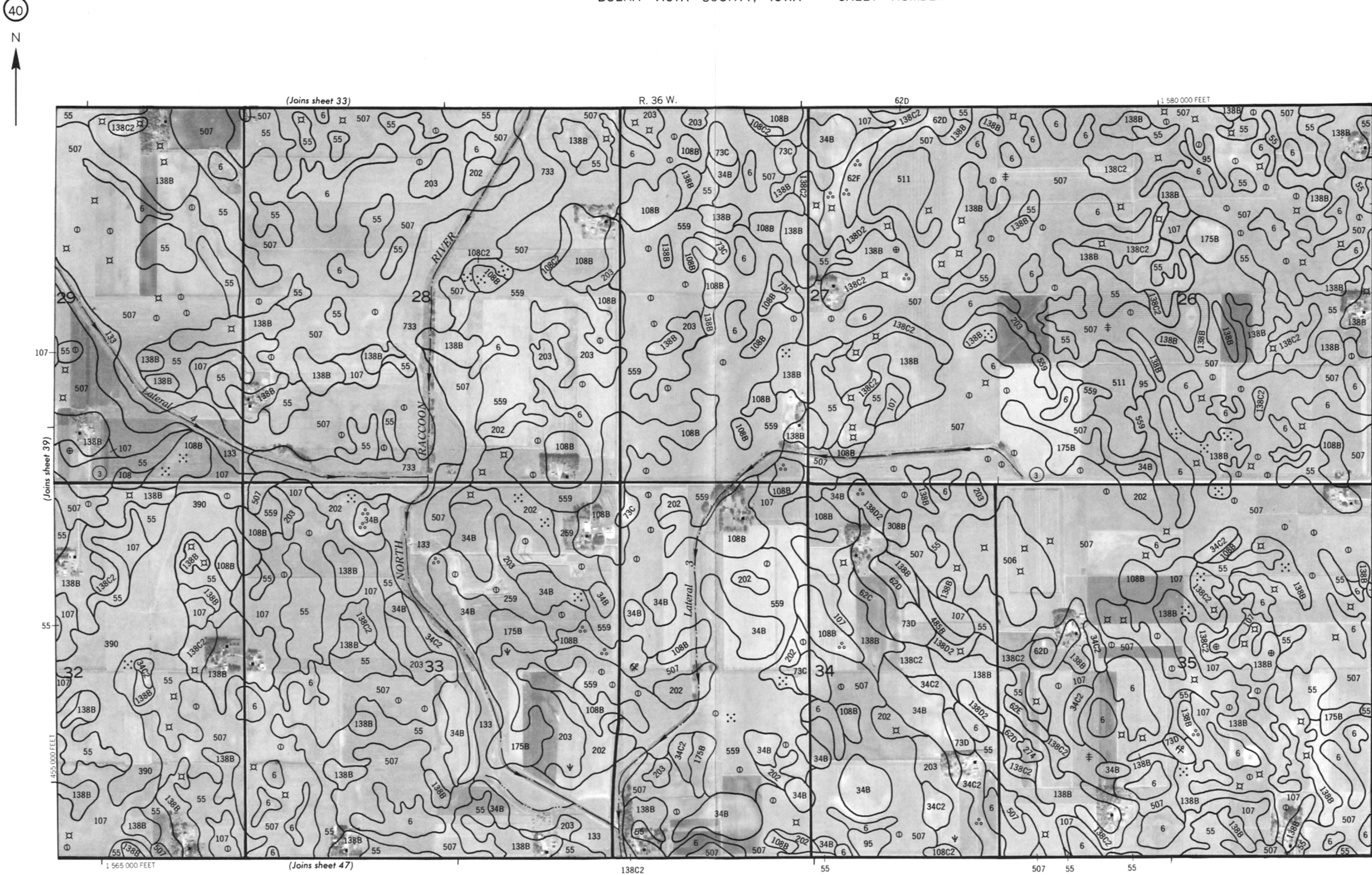

(Joins sheet 29)
R. 38 W.
1 505 000 FEET
465 000 FEET
(Joins sheet 37)
T. 92 N.
460 000 FEET
(Joins sheet 43)
1 495 000 FEET
CHEROKEE
COUNTY
Maple
Creek
Private
Airstrip
30
29
28
31
32
33


N
R. 38 W.
R. 37 W.
T. 92 N.
(Joins sheet 30)
(Joins sheet 36)
(Joins sheet 38)
(Joins sheet 44)
1 510 000 FEET
465 000 FEET
1 525 000 FEET
455 000 FEET
27
26
25
30
34
35
36
31
Brooke
Creek

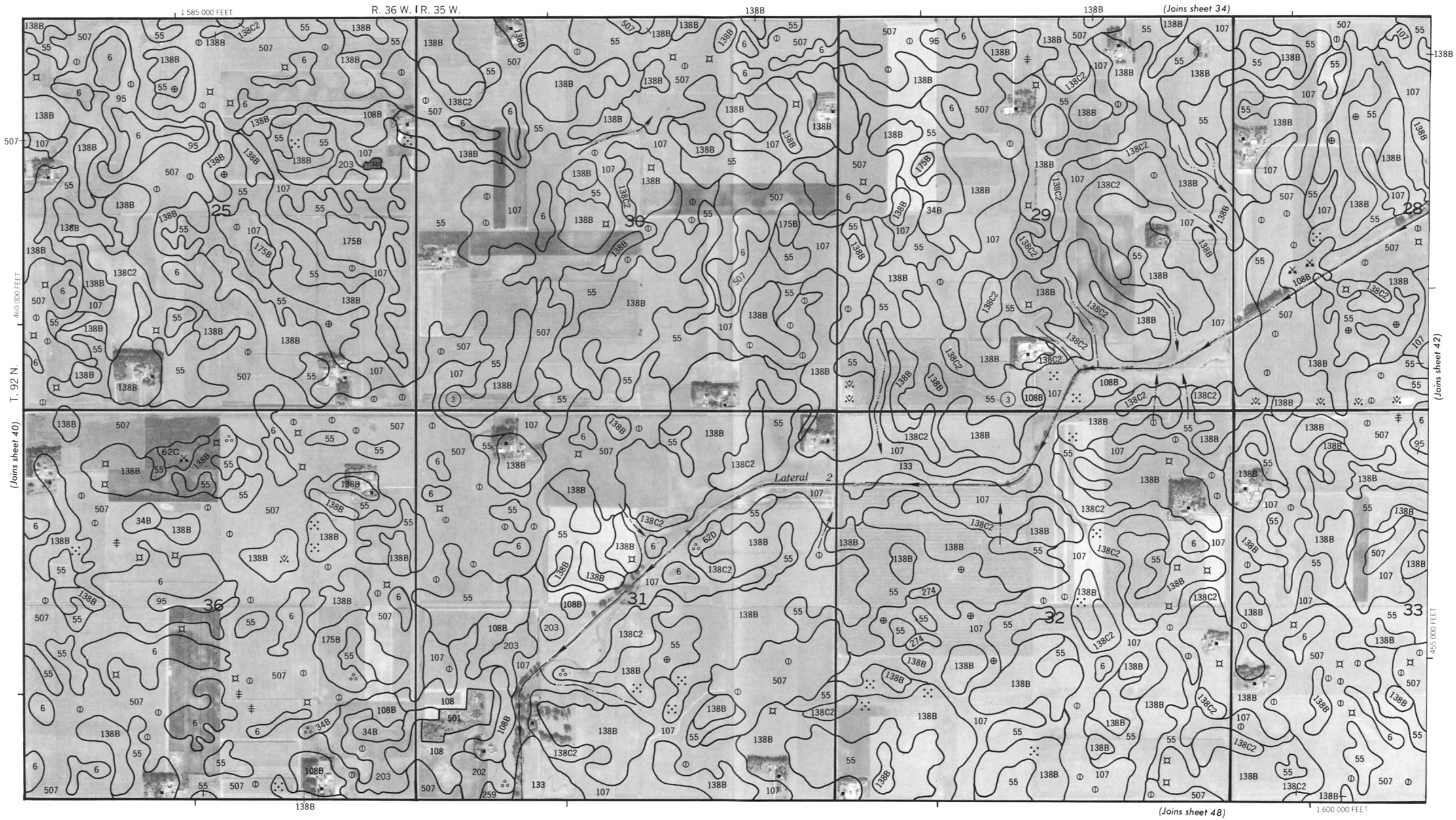

N
(Joins sheet 31)
R. 37 W.
1 545 000 FEET
(Joins sheet 39)
460 000 FEET
T. 92 N.
(Joins sheet 37)
455 000 FEET
(Joins sheet 45)
1 530 000 FEET
30
29
28
27
31
32
33
34
Brooke
Creek


N
(Joins sheet 32)
(Joins sheet 38)
(Joins sheet 40)
(Joins sheet 46)
R. 37 W.
R. 36 W.
T. 92 N.
1 550 000 FEET
1 560 000 FEET
460 000 FEET
455 000 FEET
26
25
30
29
35
36
31
32
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
Lateral
71
3

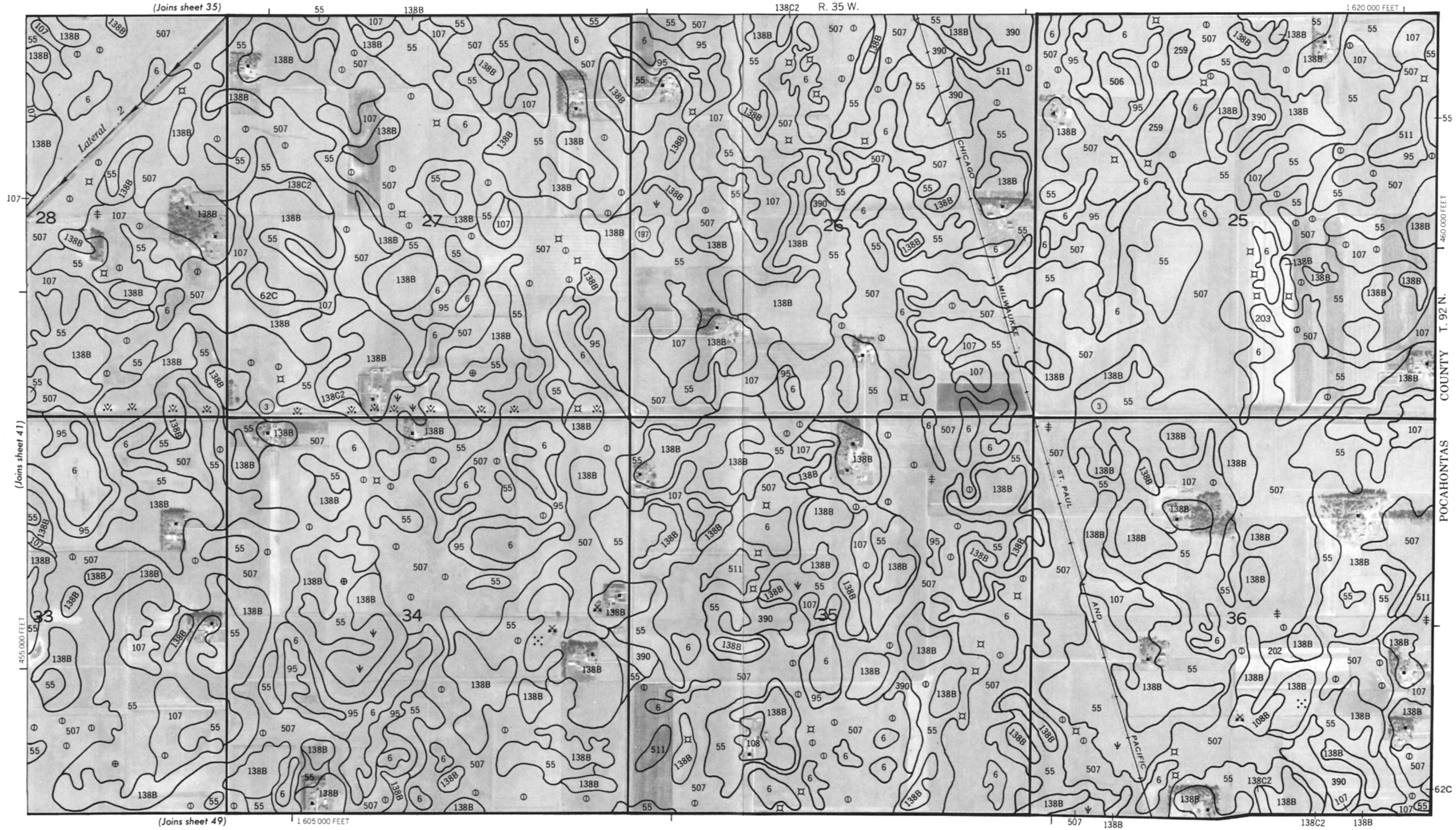
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 40

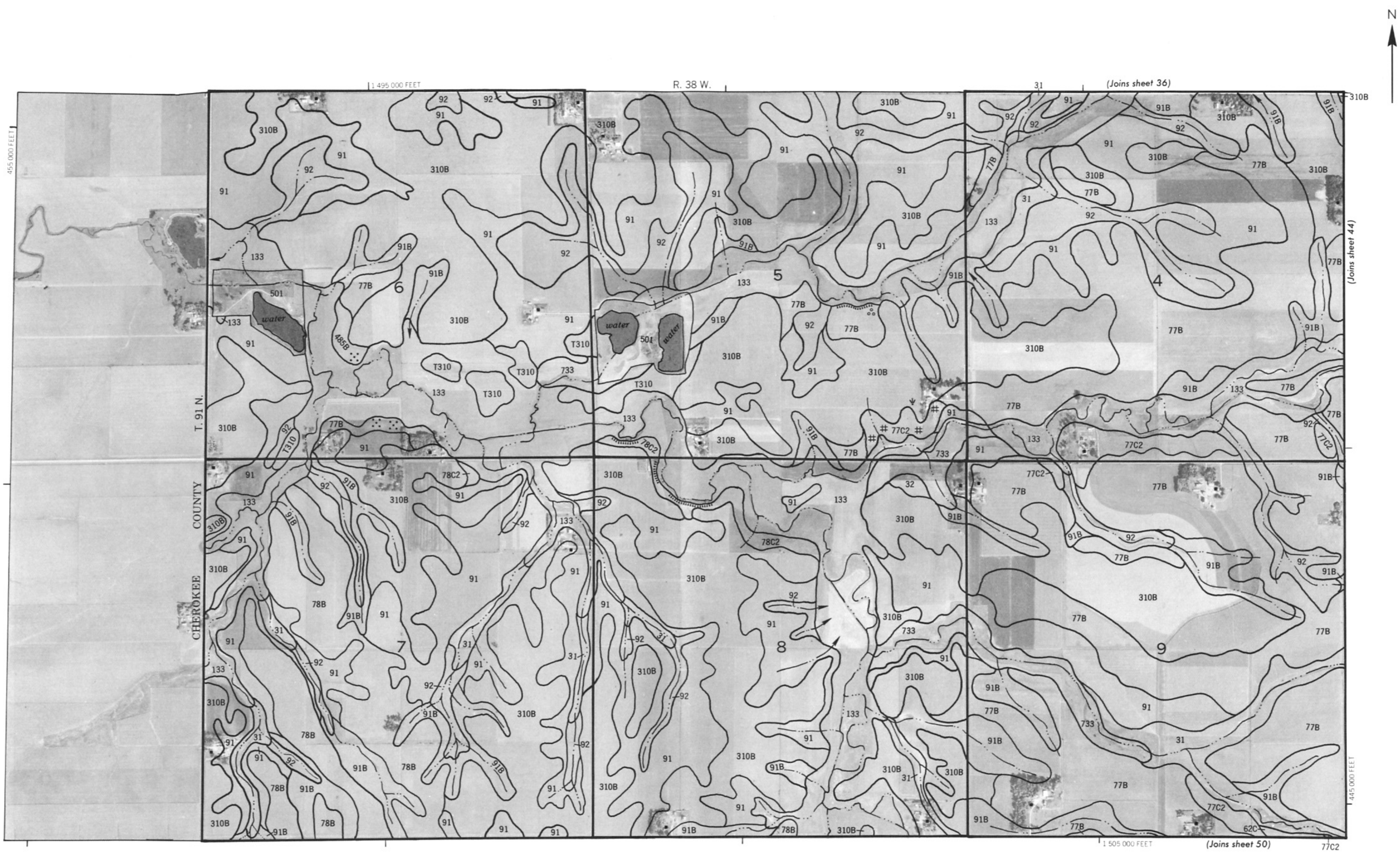


N


1 585 000 FEET
R. 36 W. | R. 35 W.
(Joins sheet 34)
(Joins sheet 42)
(Joins sheet 40)
(Joins sheet 48)
T. 92 N.
460 000 FEET
455 000 FEET
1 600 000 FEET
25
30
29
28
36
31
32
33
Lateral 2

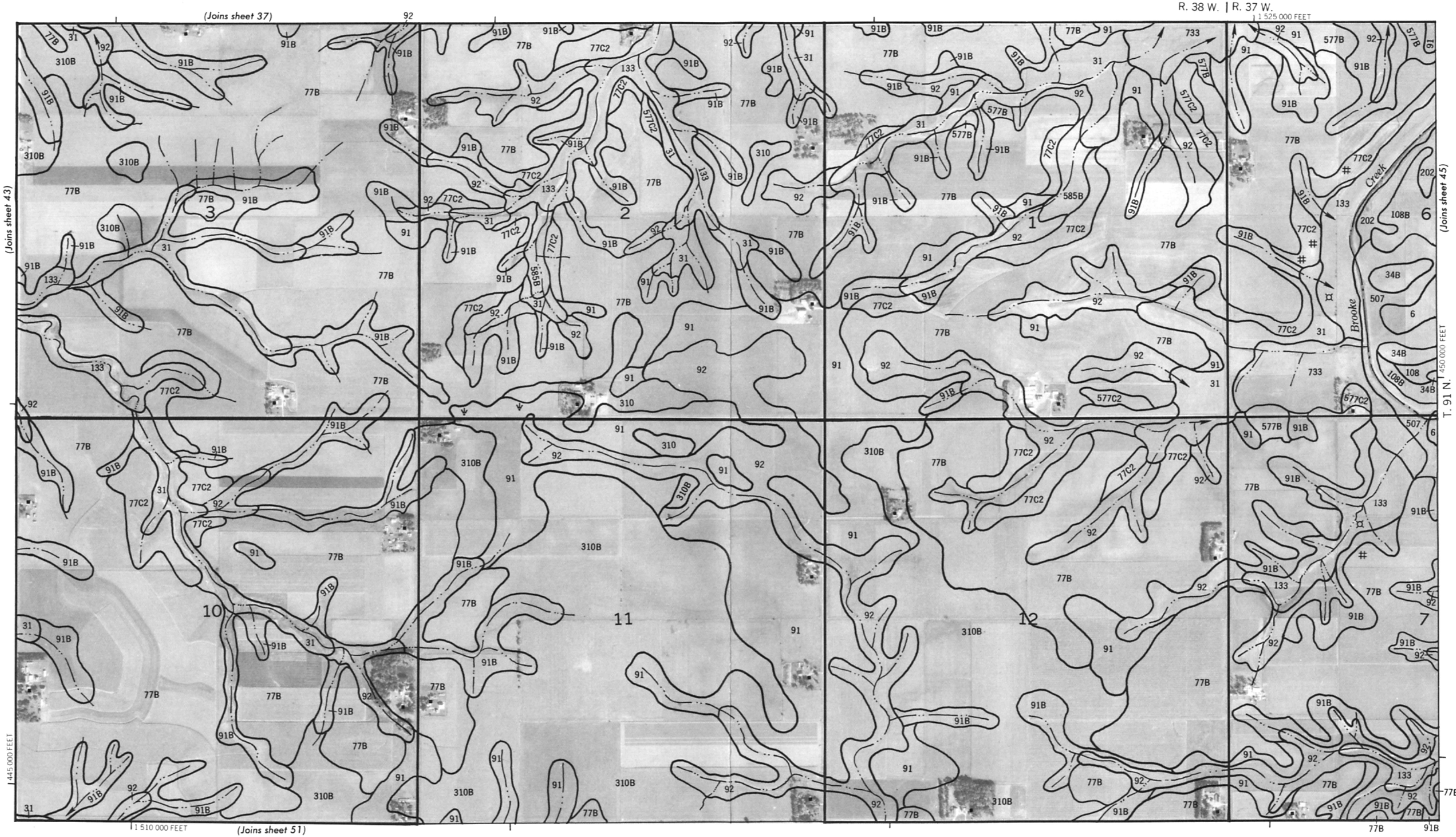
N

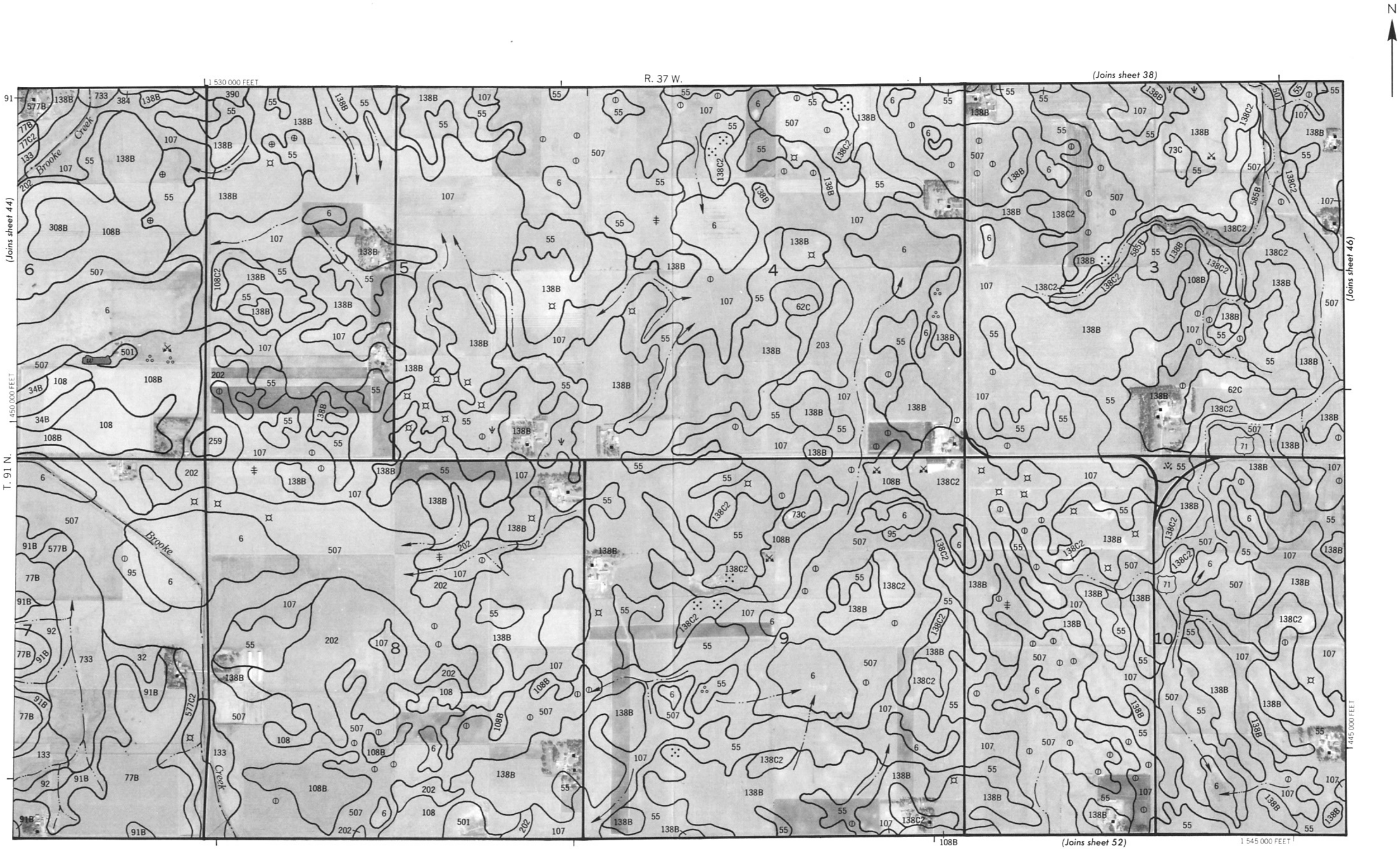

(Joins sheet 35)
R. 35 W.
1 620 000 FEET
(Joins sheet 41)
(Joins sheet 49)
1 605 000 FEET
460 000 FEET
455 000 FEET
T. 92 N.
POCAHONTAS COUNTY
28
27
26
25
33
34
35
36
Lateral 2
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC


N
R. 38 W.
T. 91 N.
CHEROKEE COUNTY
(Joins sheet 36)
(Joins sheet 44)
(Joins sheet 50)
1 495 000 FEET
1 505 000 FEET
455 000 FEET
445 000 FEET
4
5
6
7
8
9
water
501
310B
91
92
91B
77B
133
T310
733
78C2
77C2
31
32
78B
485B
62C

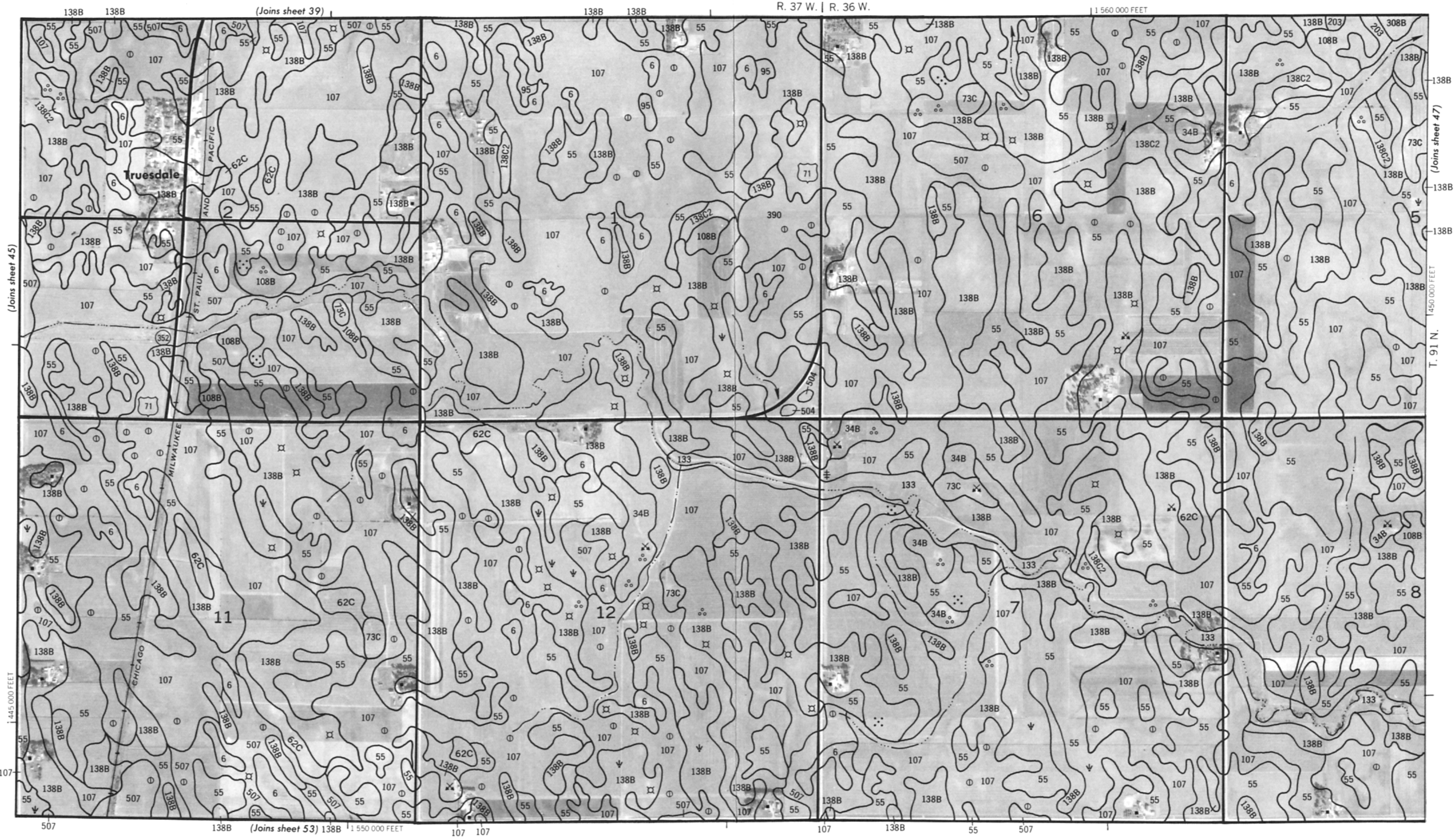
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 44

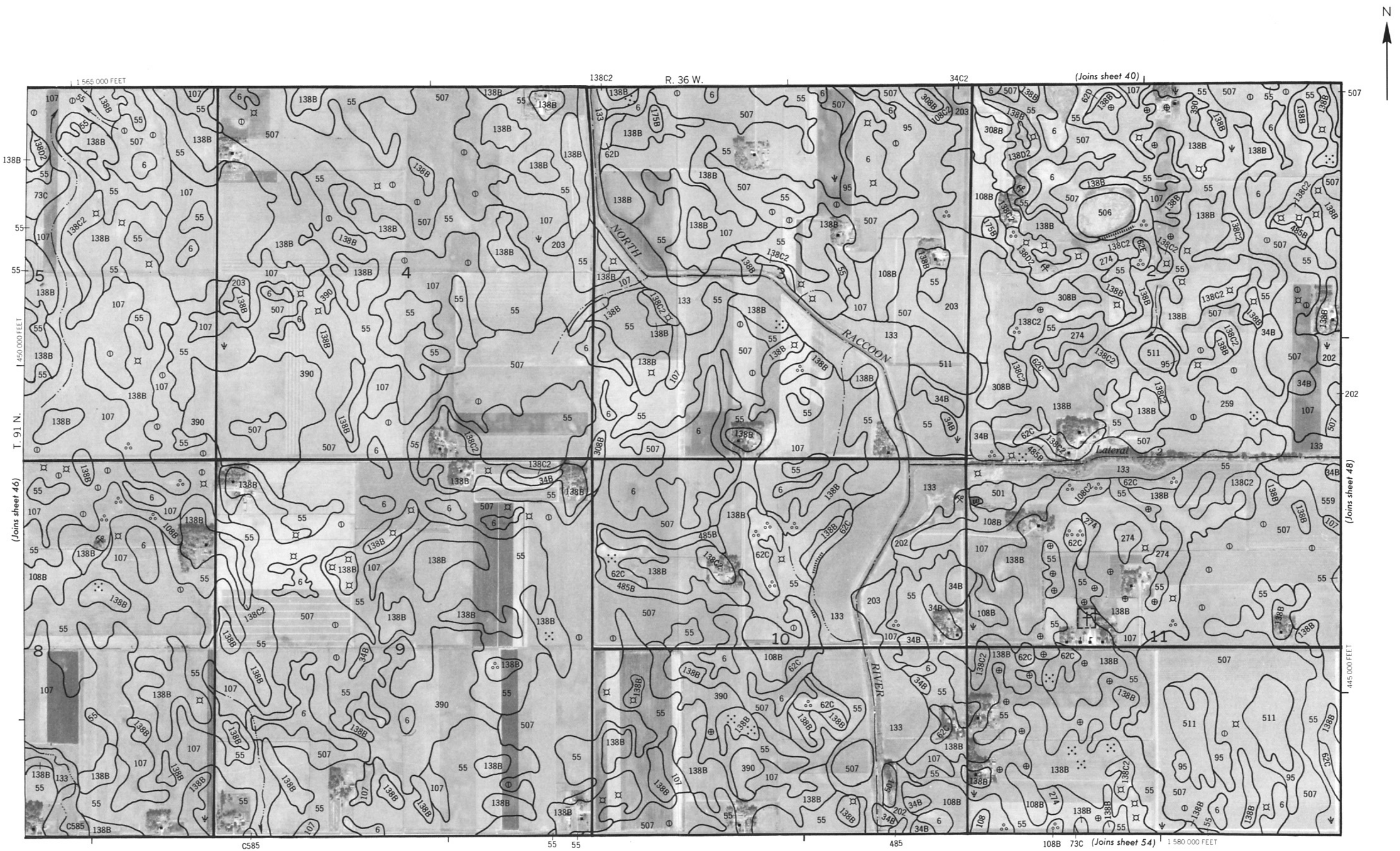
N




N
R. 37 W.
T. 91 N.
(Joins sheet 38)
(Joins sheet 44)
(Joins sheet 46)
(Joins sheet 52)
1 530 000 FEET
1 545 000 FEET
450 000 FEET
445 000 FEET
Brooke Creek
Brooke
Creek
6
5
4
3
7
8
9
10
71

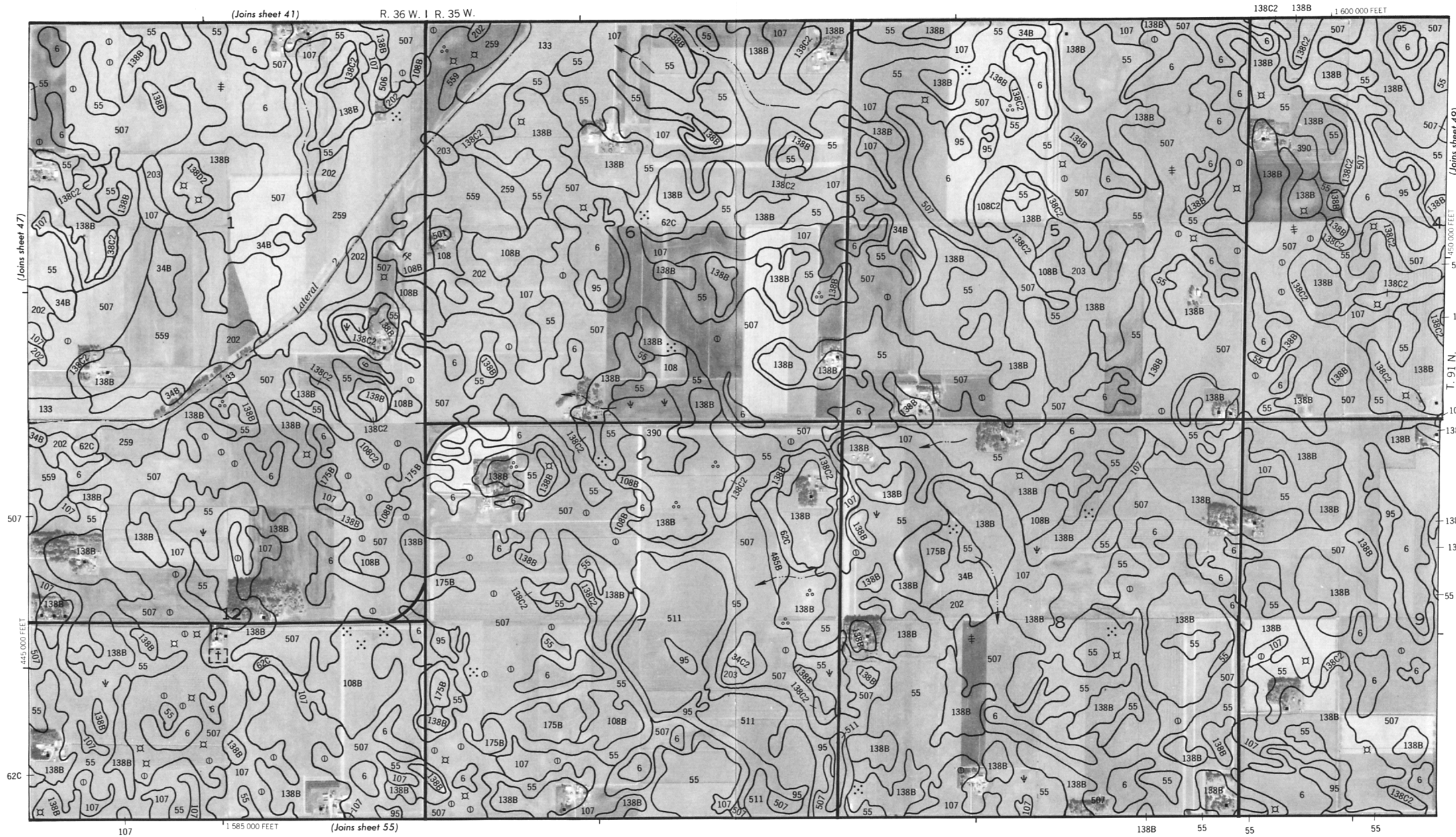
N

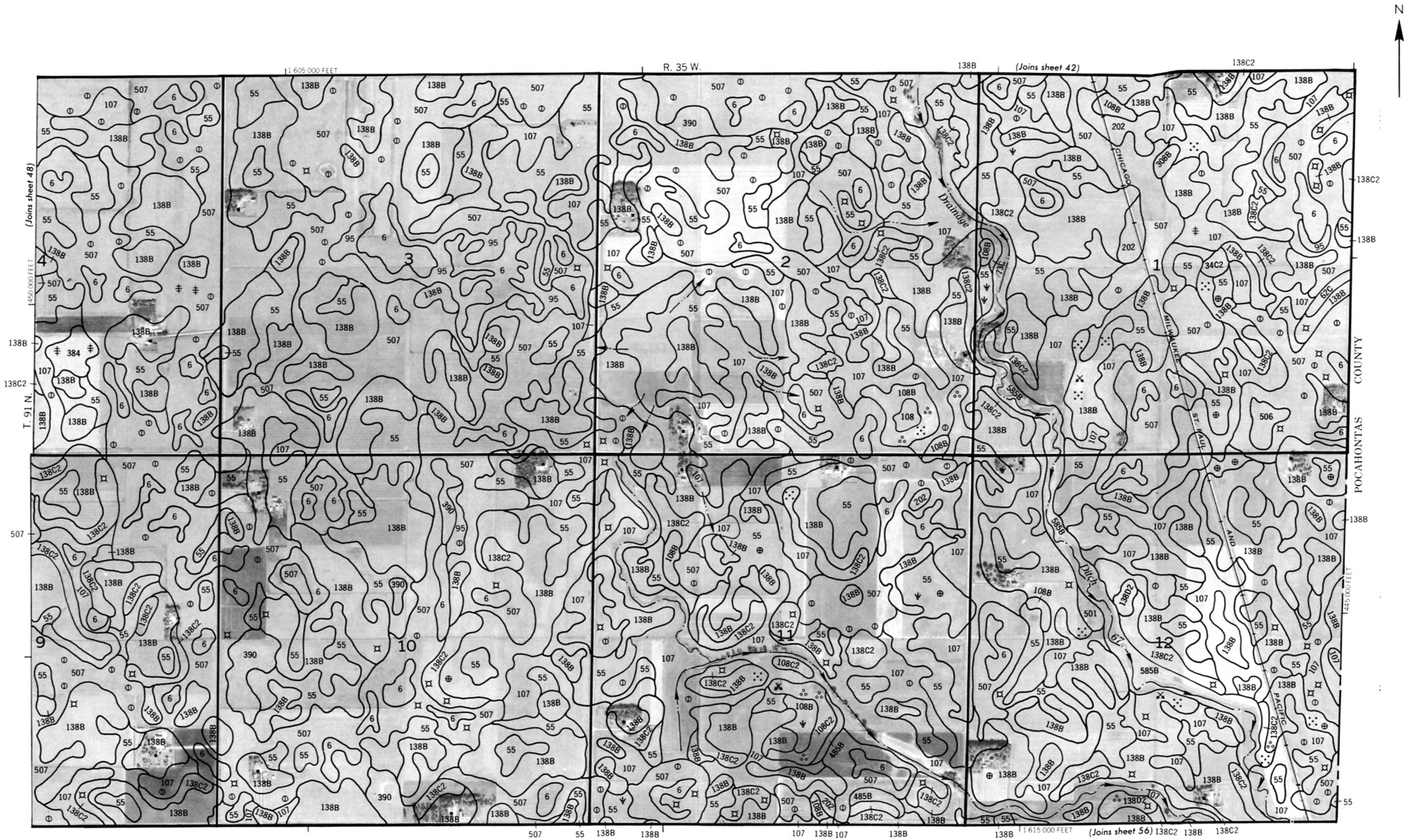

(Joins sheet 39)
R. 37 W. | R. 36 W.
1 560 000 FEET
(Joins sheet 47)
(Joins sheet 45)
T. 91 N.
450 000 FEET
445 000 FEET
(Joins sheet 53)
1 550 000 FEET
Truesdale
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
71
352
1
2
5
6
7
8
11
12


47
N
(Joins sheet 40)
R. 36 W.
1 565 000 FEET
450 000 FEET
445 000 FEET
1 580 000 FEET
T. 91 N.
(Joins sheet 46)
(Joins sheet 48)
(Joins sheet 54)
NORTH
RACCOON
RIVER
Lateral 2

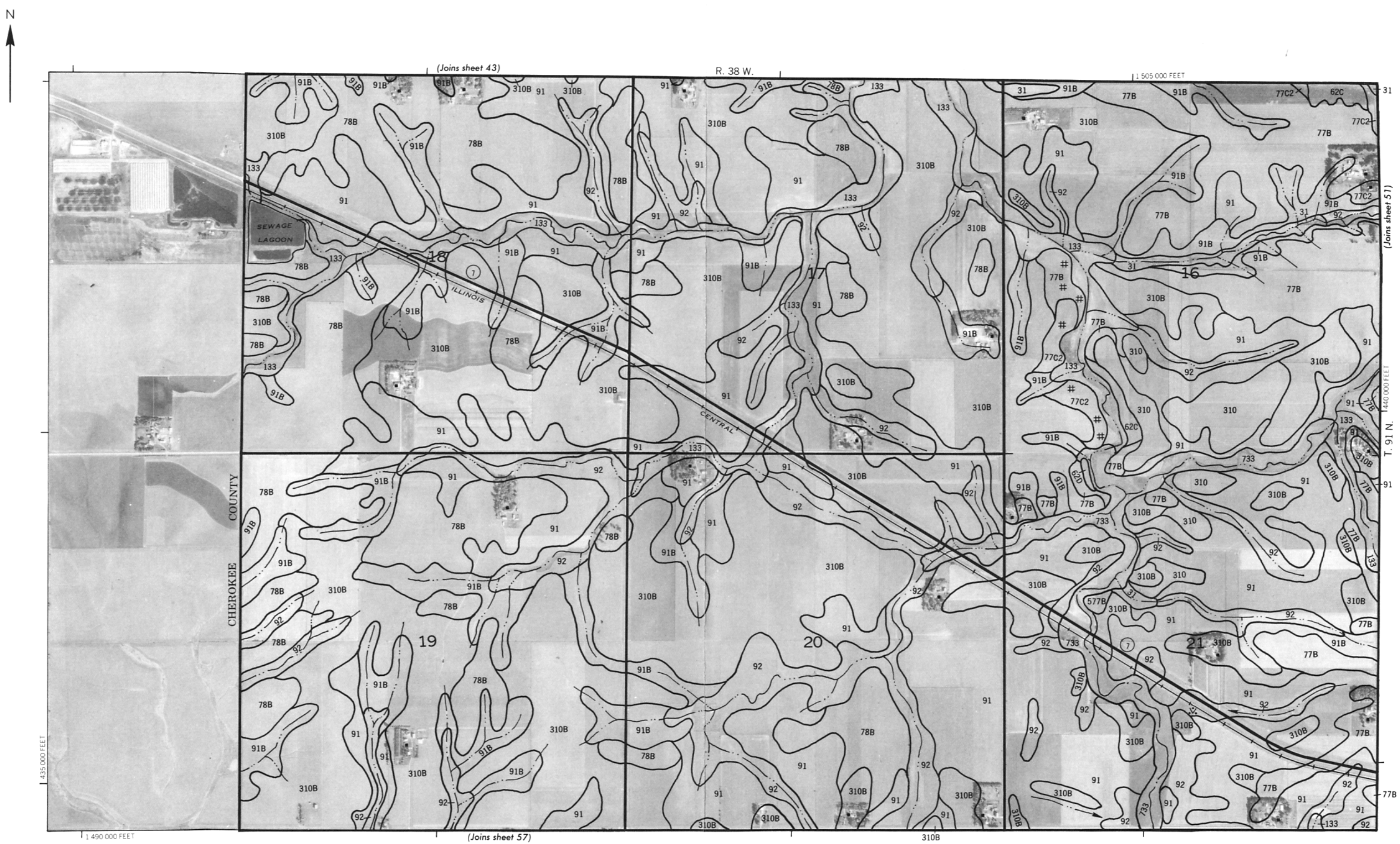
N

BUENA VISTA COUNTY, IOWA — SHEET NUMBER 48



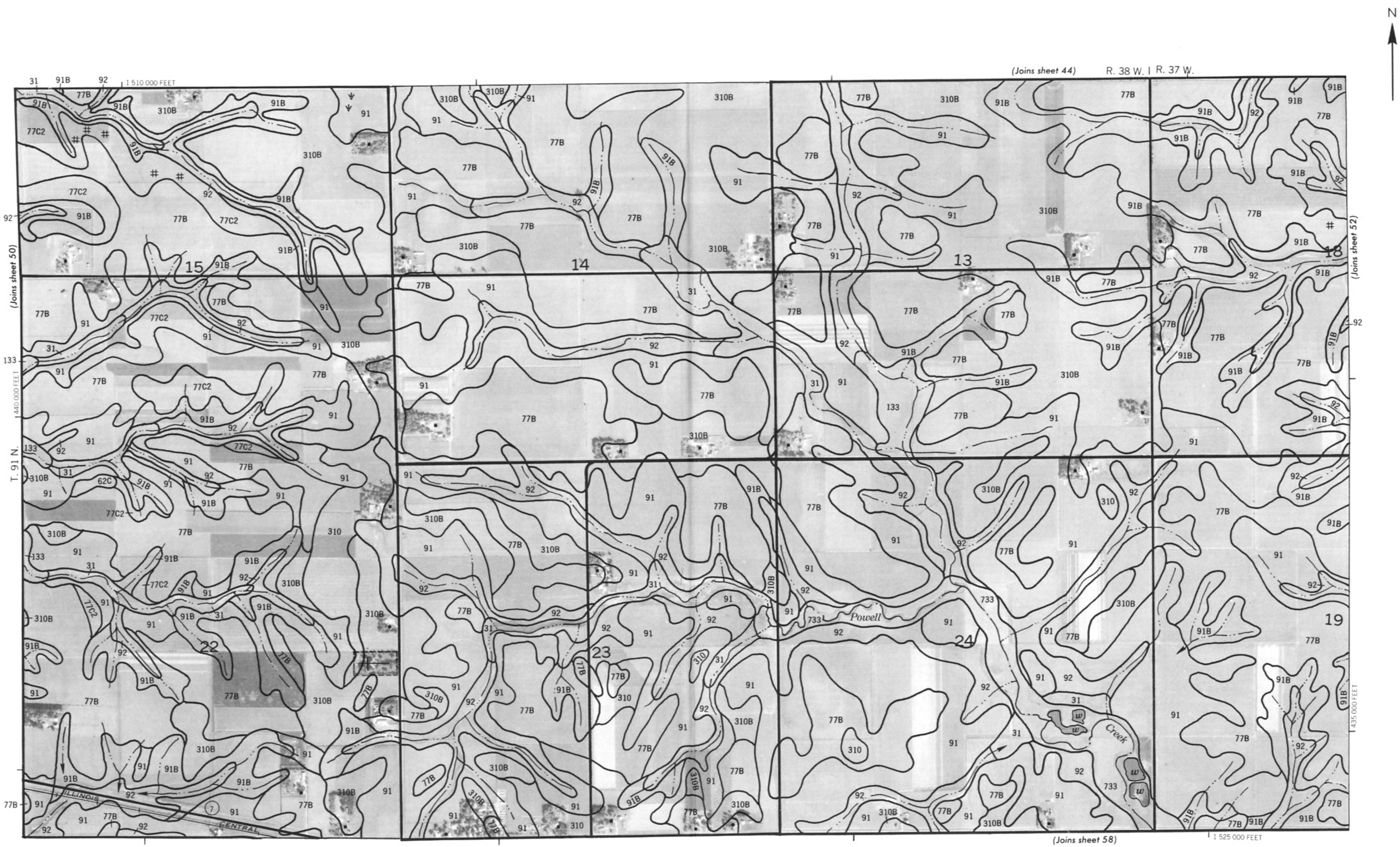

N
R. 35 W.
(Joins sheet 42)
(Joins sheet 48)
(Joins sheet 56)
1 605 000 FEET
1 615 000 FEET
450 000 FEET
445 000 FEET
T. 91 N.
POCAHONTAS COUNTY
Drainage
Ditch
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
1
2
3
4
9
10
11
12

BUENA VISTA COUNTY, IOWA — SHEET NUMBER 50

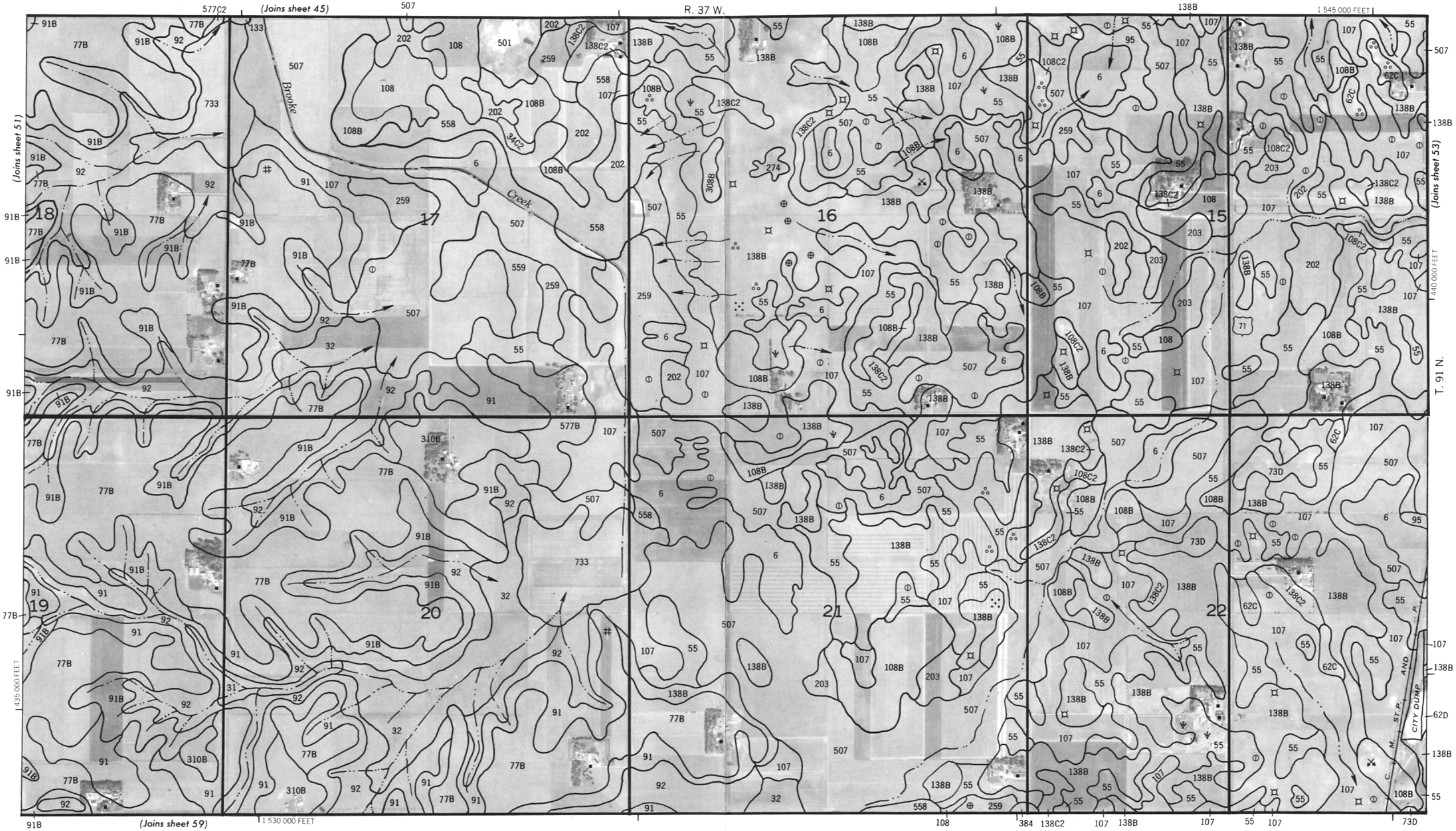


BUENA VISTA COUNTY, IOWA — SHEET NUMBER 51

51

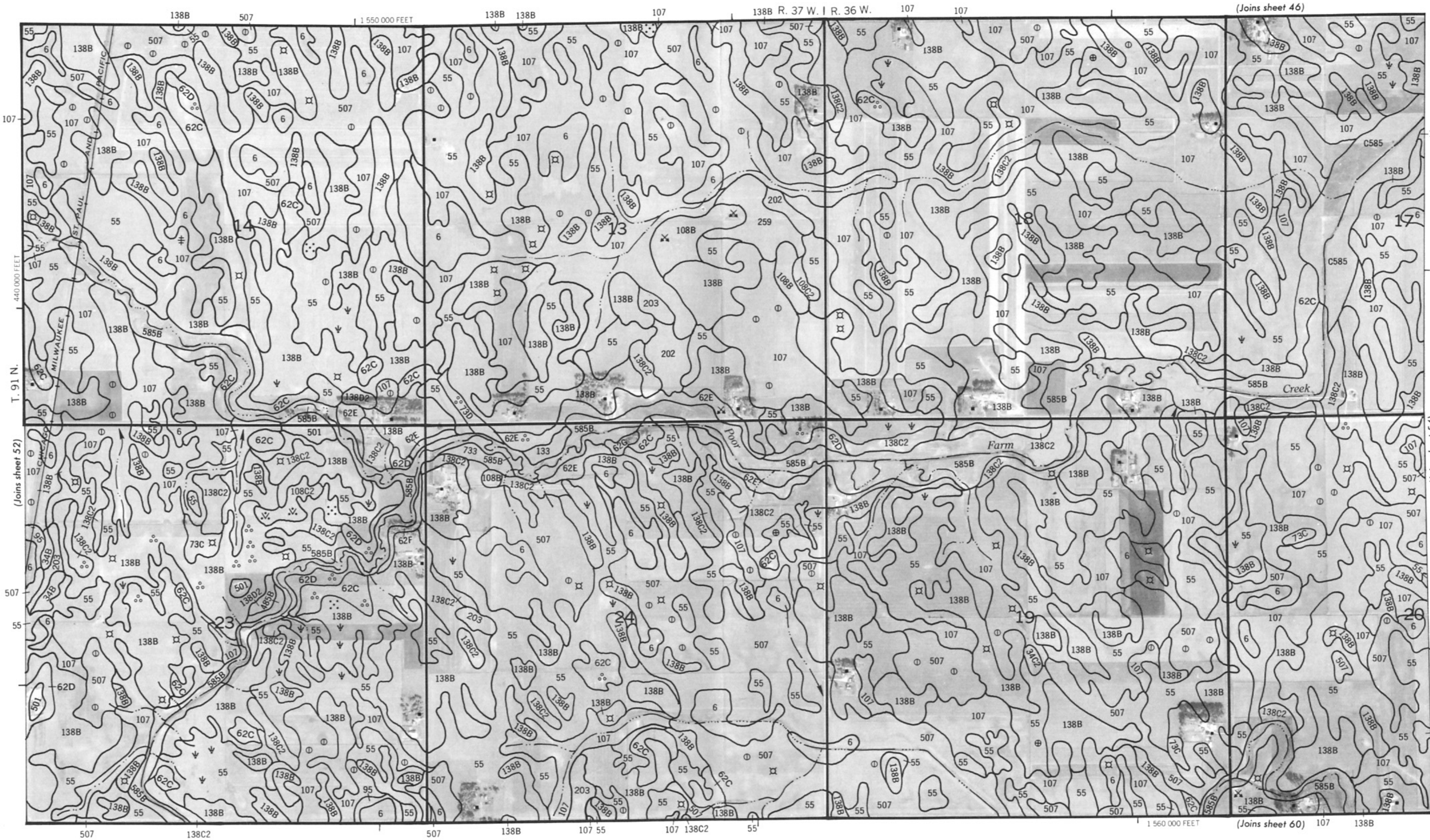


N

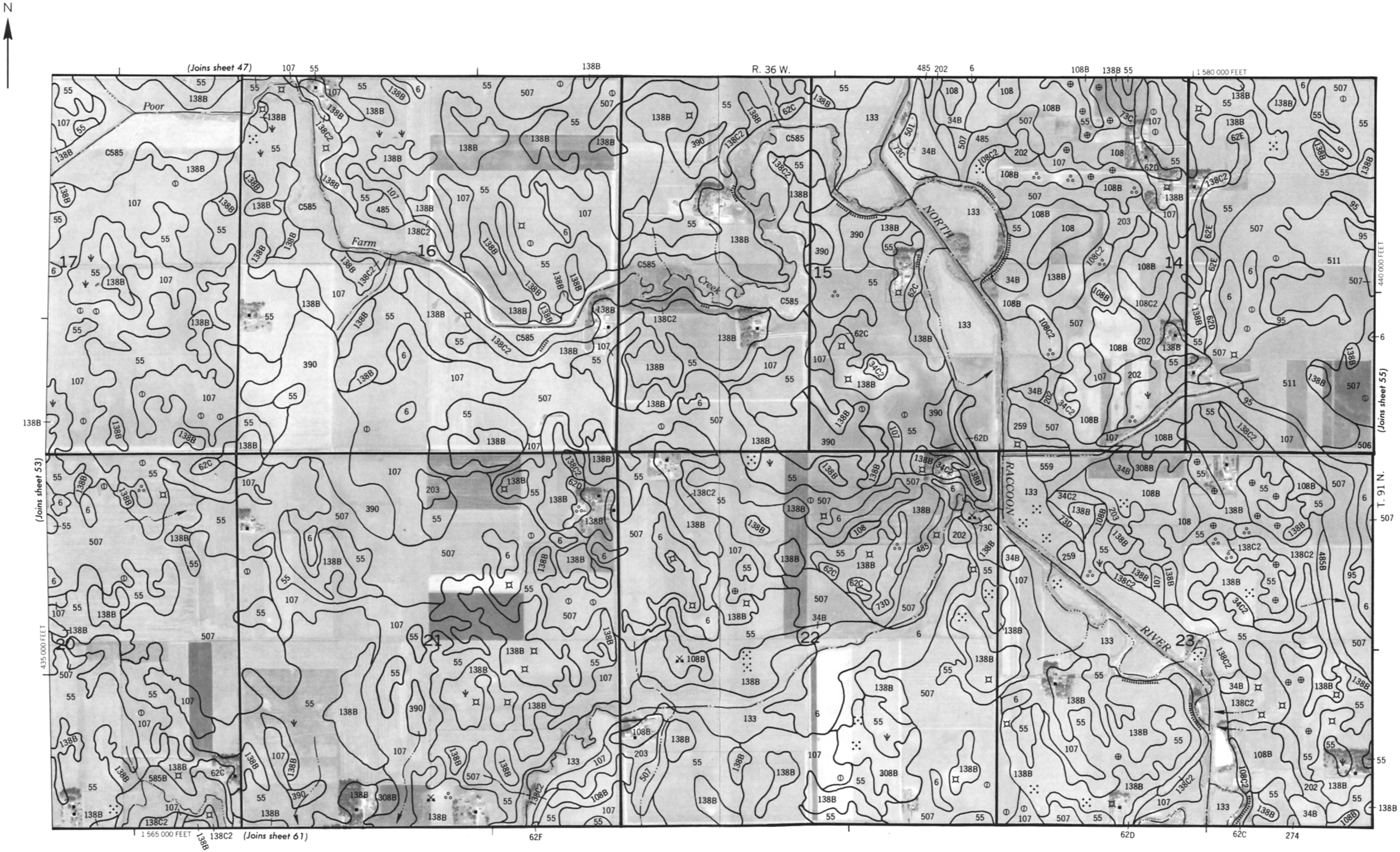

(Joins sheet 45)
R. 37 W.
1 545 000 FEET
(Joins sheet 51)
(Joins sheet 53)
T. 91 N.
440 000 FEET
435 000 FEET
(Joins sheet 59)
1 530 000 FEET
Brooke Creek
17
18
16
15
19
20
21
22
C. M. St. P. AND P.
CITY DUMP

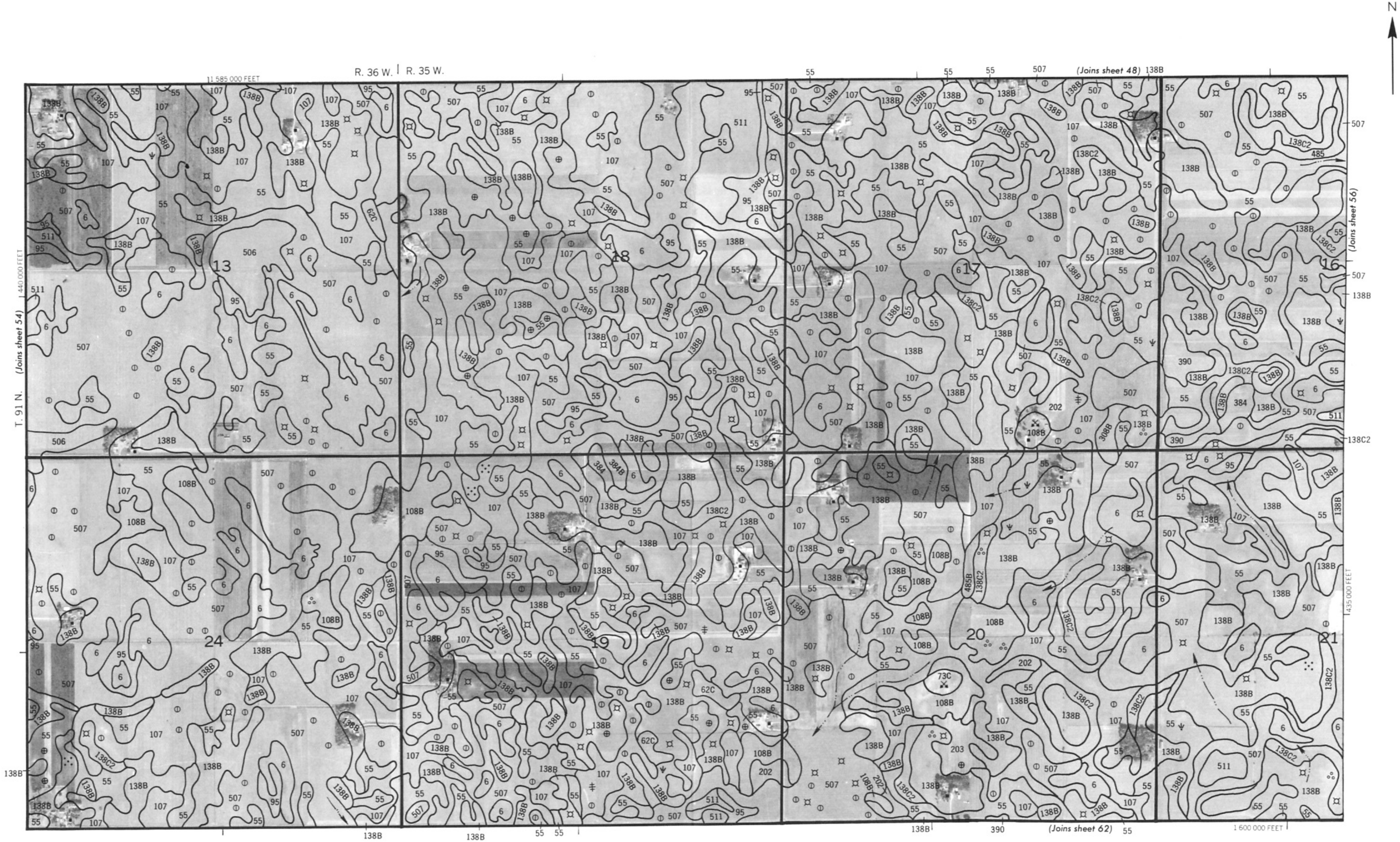
53

N


(Joins sheet 46)
R. 37 W. | R. 36 W.
1 550 000 FEET
440 000 FEET
T. 91 N.
(Joins sheet 52)
(Joins sheet 54)
435 000 FEET
1 560 000 FEET
(Joins sheet 60)
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
Poor
Farm
Creek
14
13
18
17
23
24
19
20

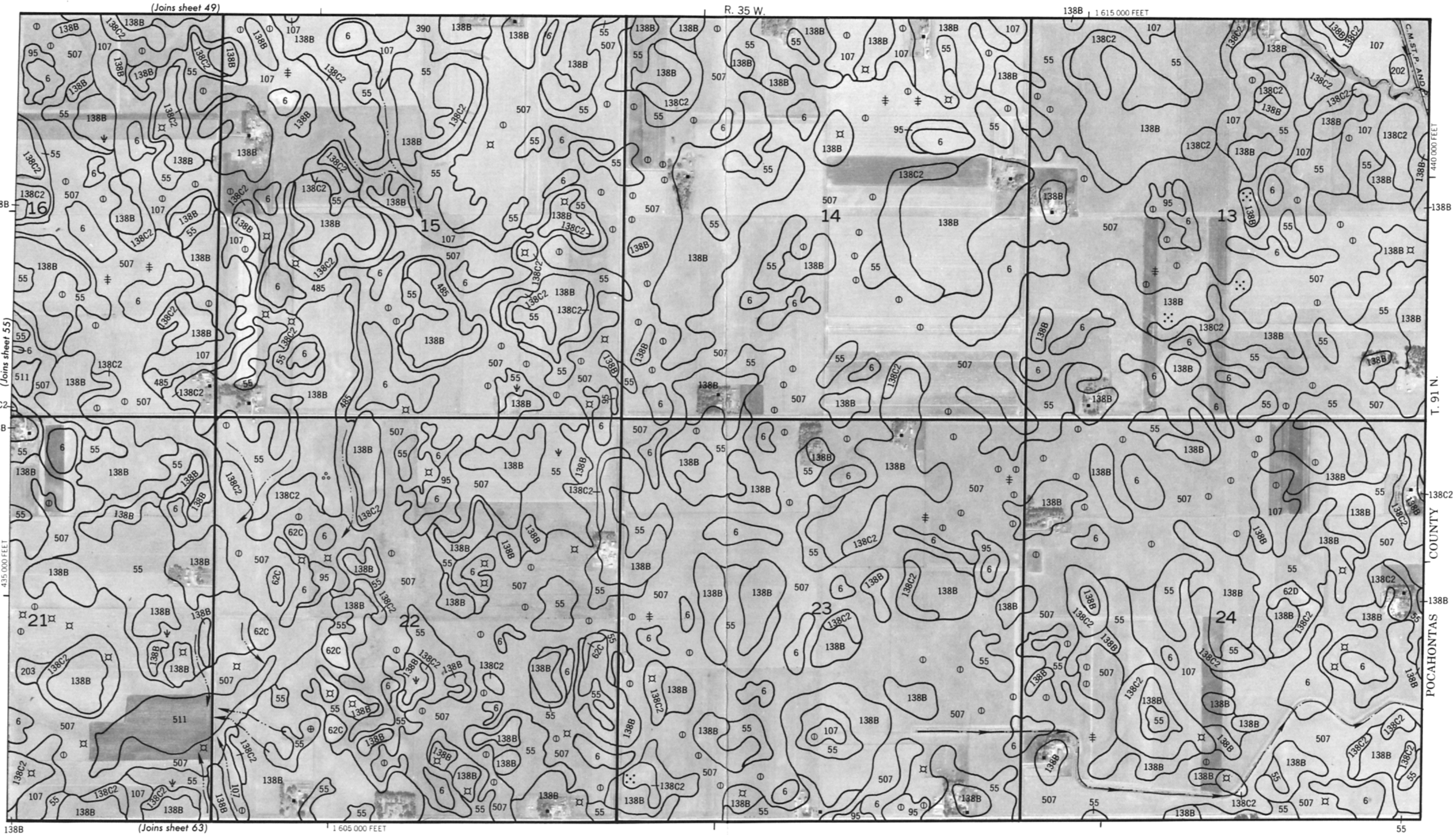
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 54

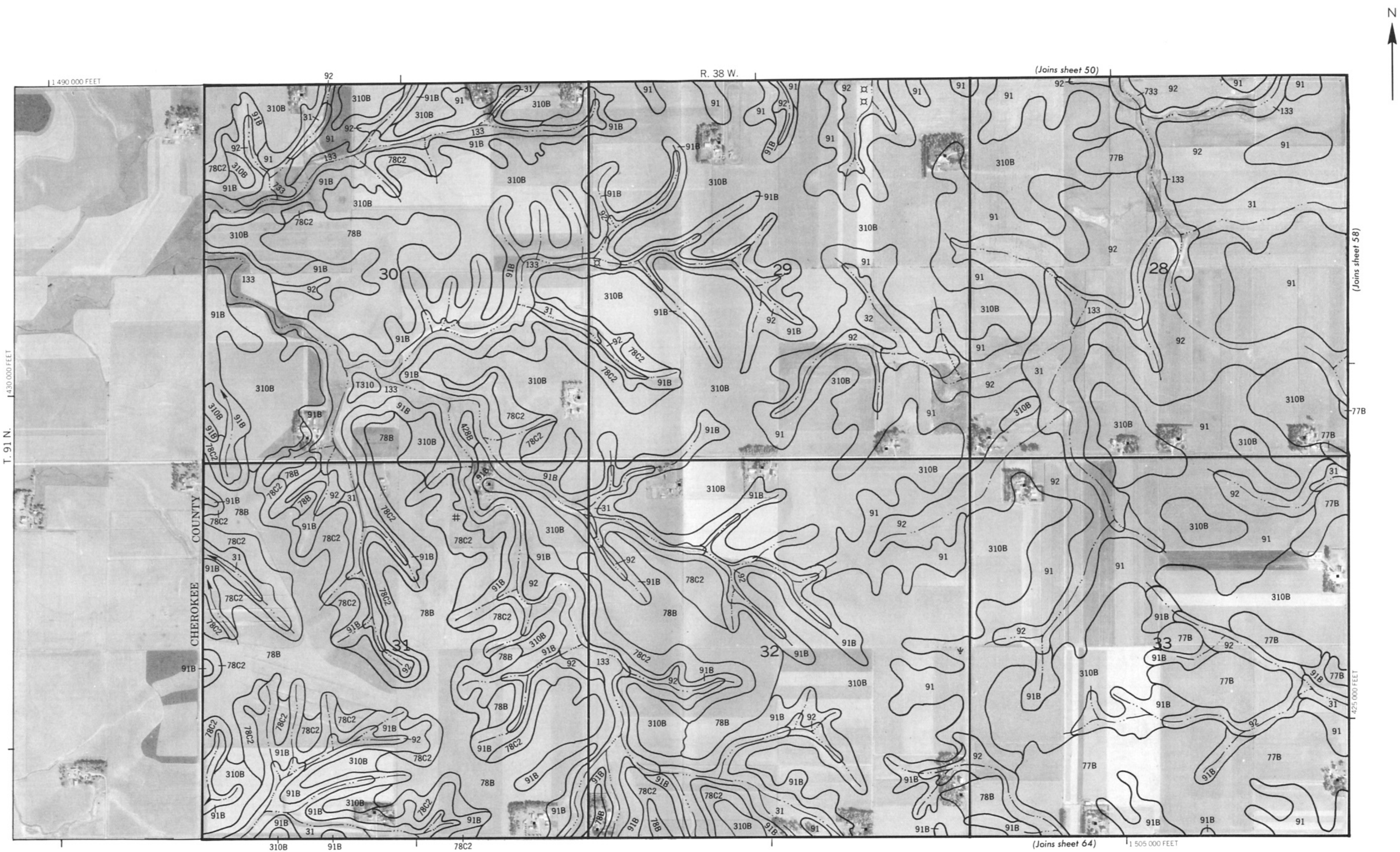


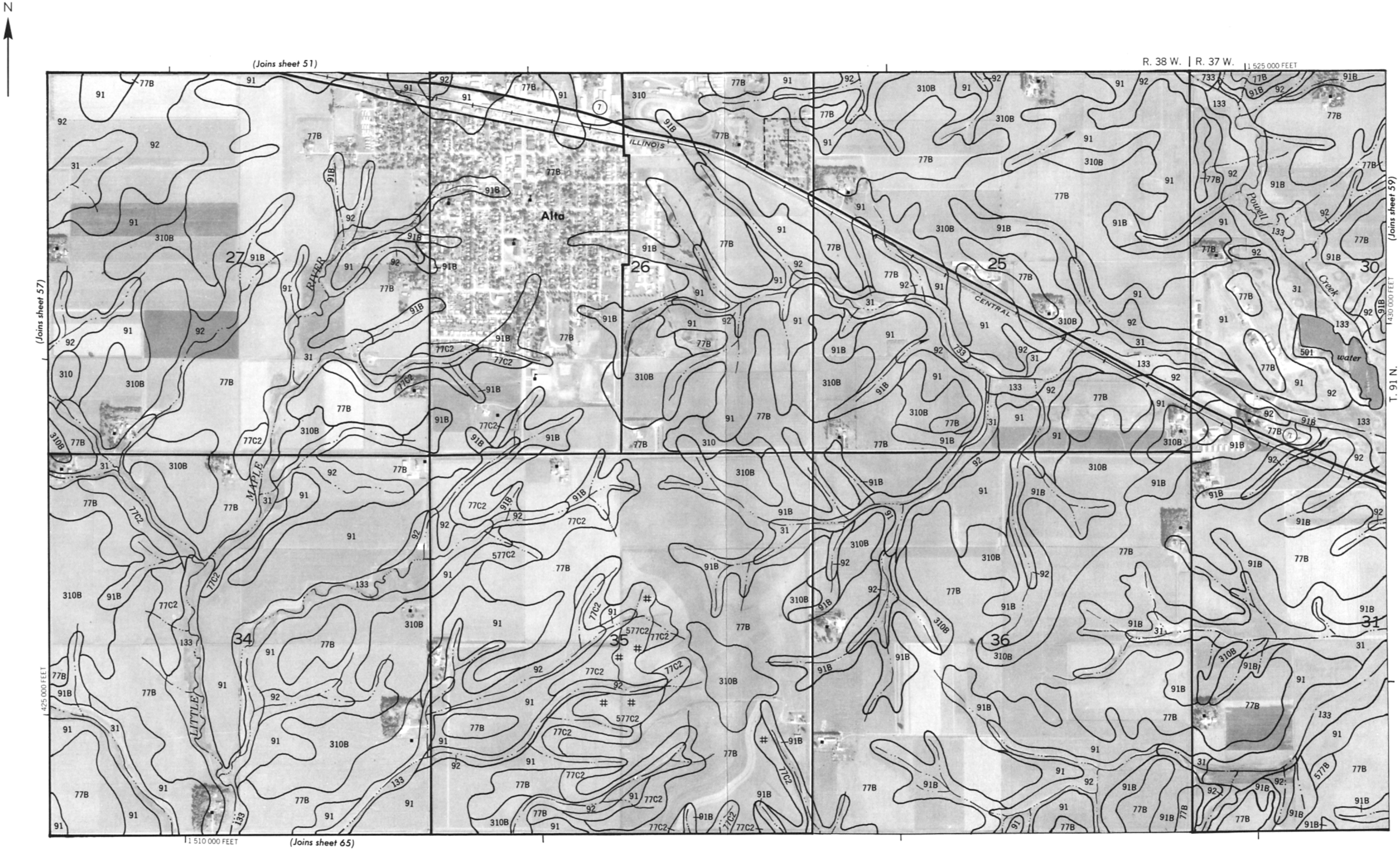

N
R. 36 W.
R. 35 W.
1 585 000 FEET
(Joins sheet 48)
(Joins sheet 56)
(Joins sheet 62)
(Joins sheet 54)
T. 91 N.
440 000 FEET
435 000 FEET
1 600 000 FEET
13
18
17
16
24
19
20
21

BUENA VISTA COUNTY, IOWA — SHEET NUMBER 56

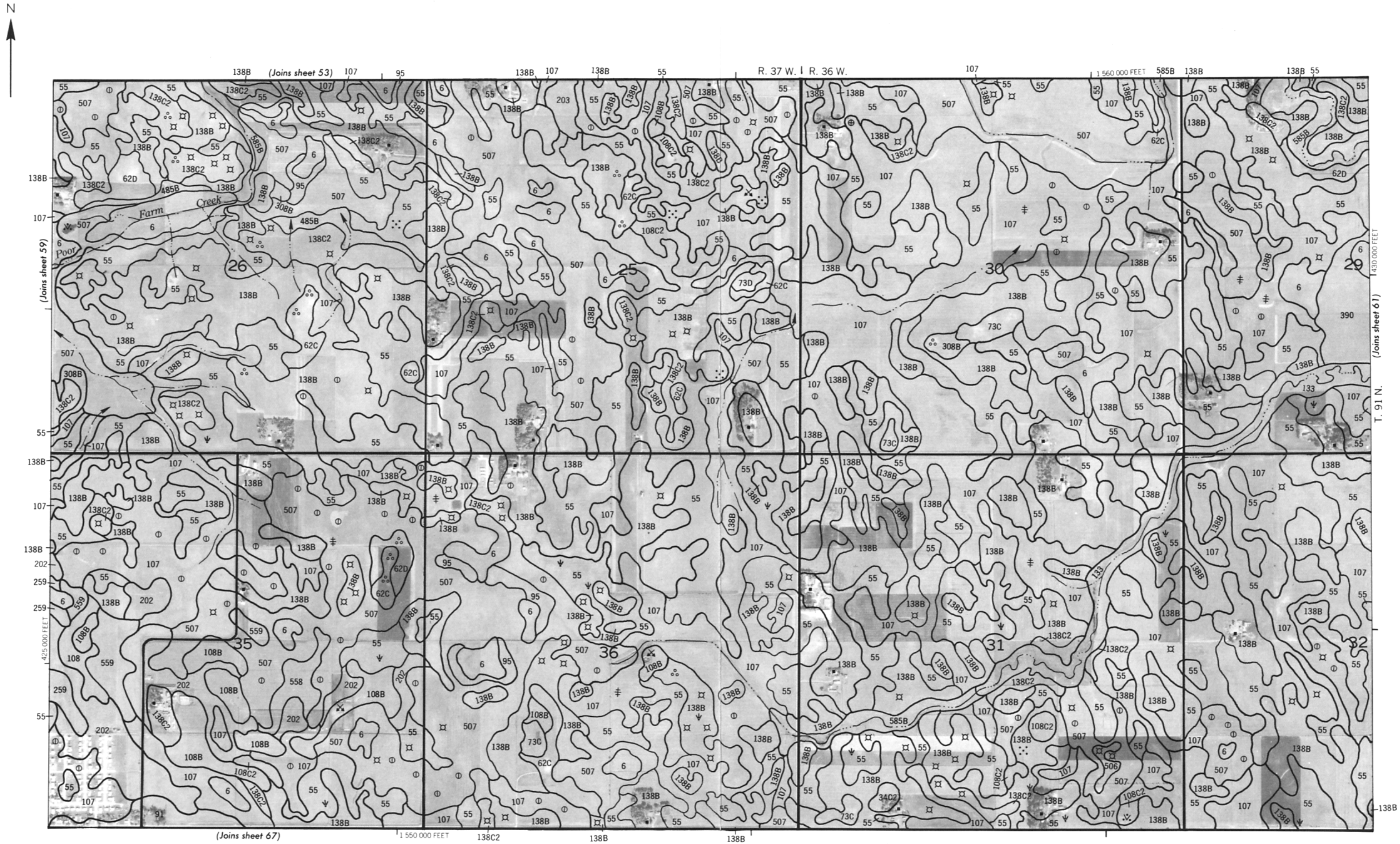
N

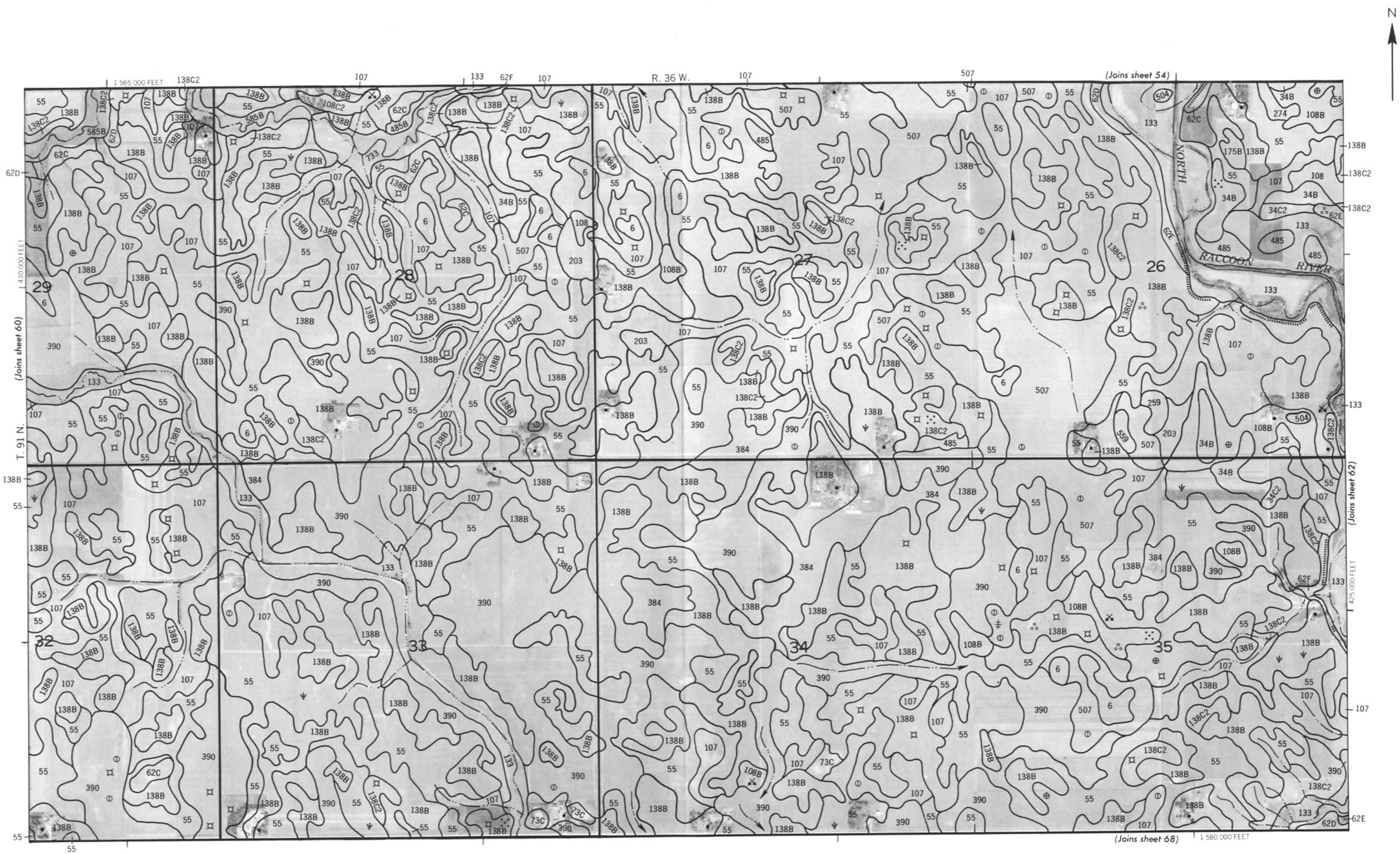



57
N
1 490 000 FEET
R. 38 W.
(Joins sheet 50)
(Joins sheet 58)
(Joins sheet 64)
1 505 000 FEET
430 000 FEET
425 000 FEET
T. 91 N.
CHEROKEE COUNTY
30
29
28
31
32
33

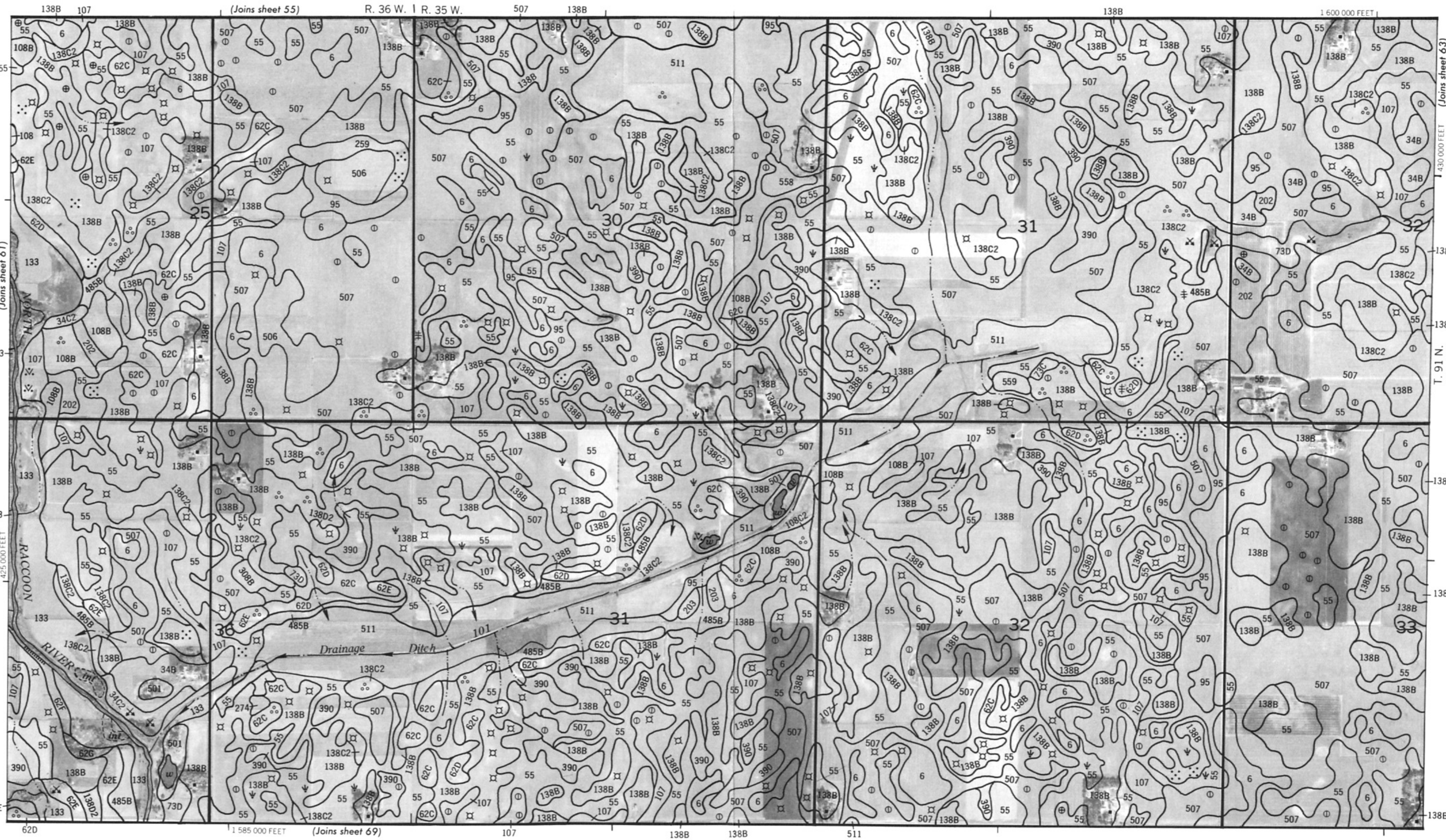

N
(Joins sheet 51)
R. 38 W.
R. 37 W.
1 525 000 FEET
(Joins sheet 57)
(Joins sheet 59)
430 000 FEET
T. 91 N.
425 000 FEET
1 510 000 FEET
(Joins sheet 65)
Alto
ILLINOIS
CENTRAL
LITTLE
MAPLE
RIVER
Powell
Creek
water
27
26
25
30
34
35
36
31

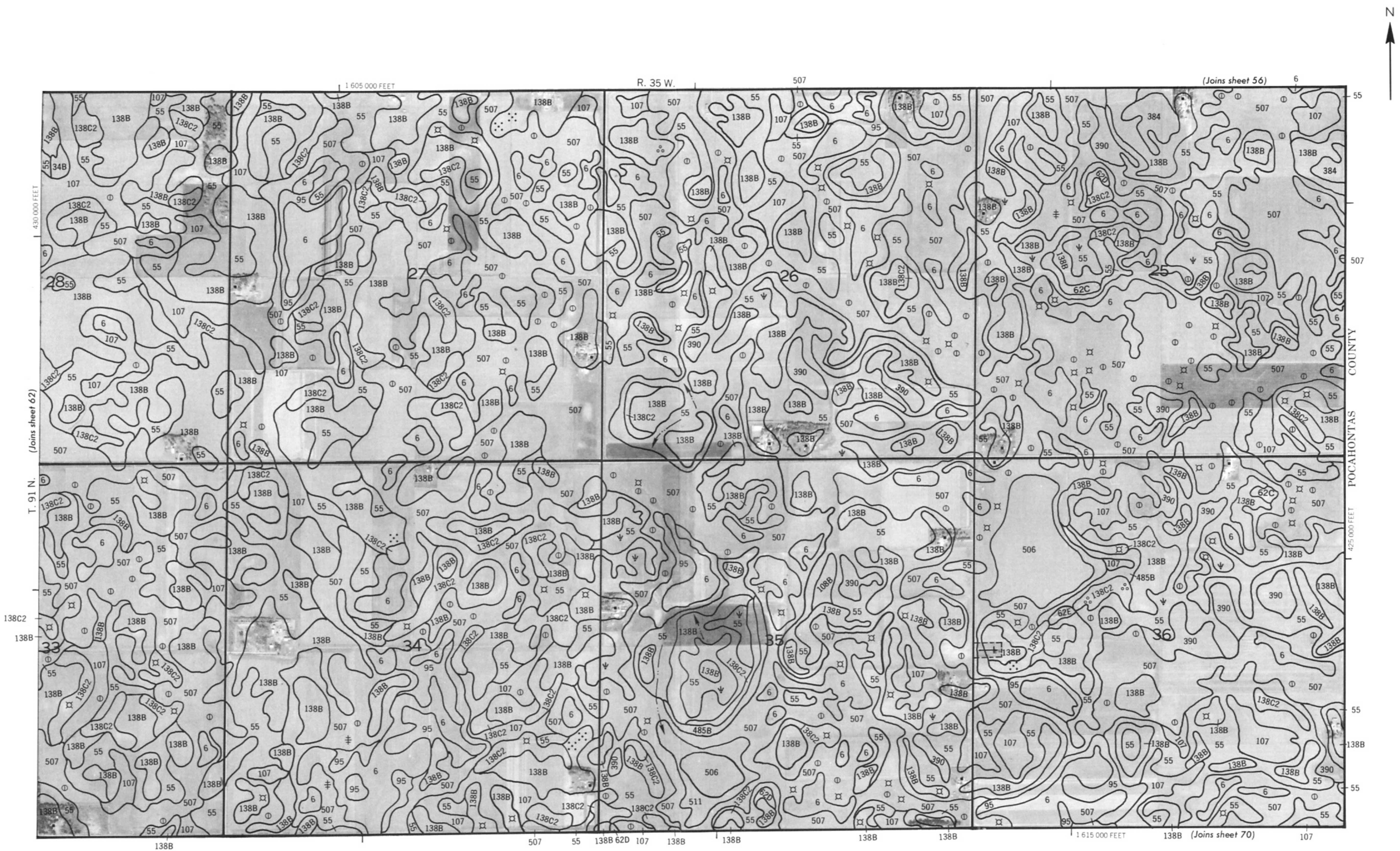

N
R. 37 W.
T. 91 N.
1 530 000 FEET
1 545 000 FEET
430 000 FEET
425 000 FEET
(Joins sheet 52)
(Joins sheet 58)
(Joins sheet 60)
(Joins sheet 66)
Powell
Creek
Poor
Farm
Creek
STORM
LAKE
ILLINOIS
CENTRAL
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
27
28
29
30
31
32
33
34
7
71
110


N
(Joins sheet 53)
(Joins sheet 59)
(Joins sheet 61)
(Joins sheet 67)
R. 37 W.
R. 36 W.
T. 91 N.
1 560 000 FEET
1 550 000 FEET
430 000 FEET
425 000 FEET
Farm Creek
Poor
26
25
30
29
35
36
31
32

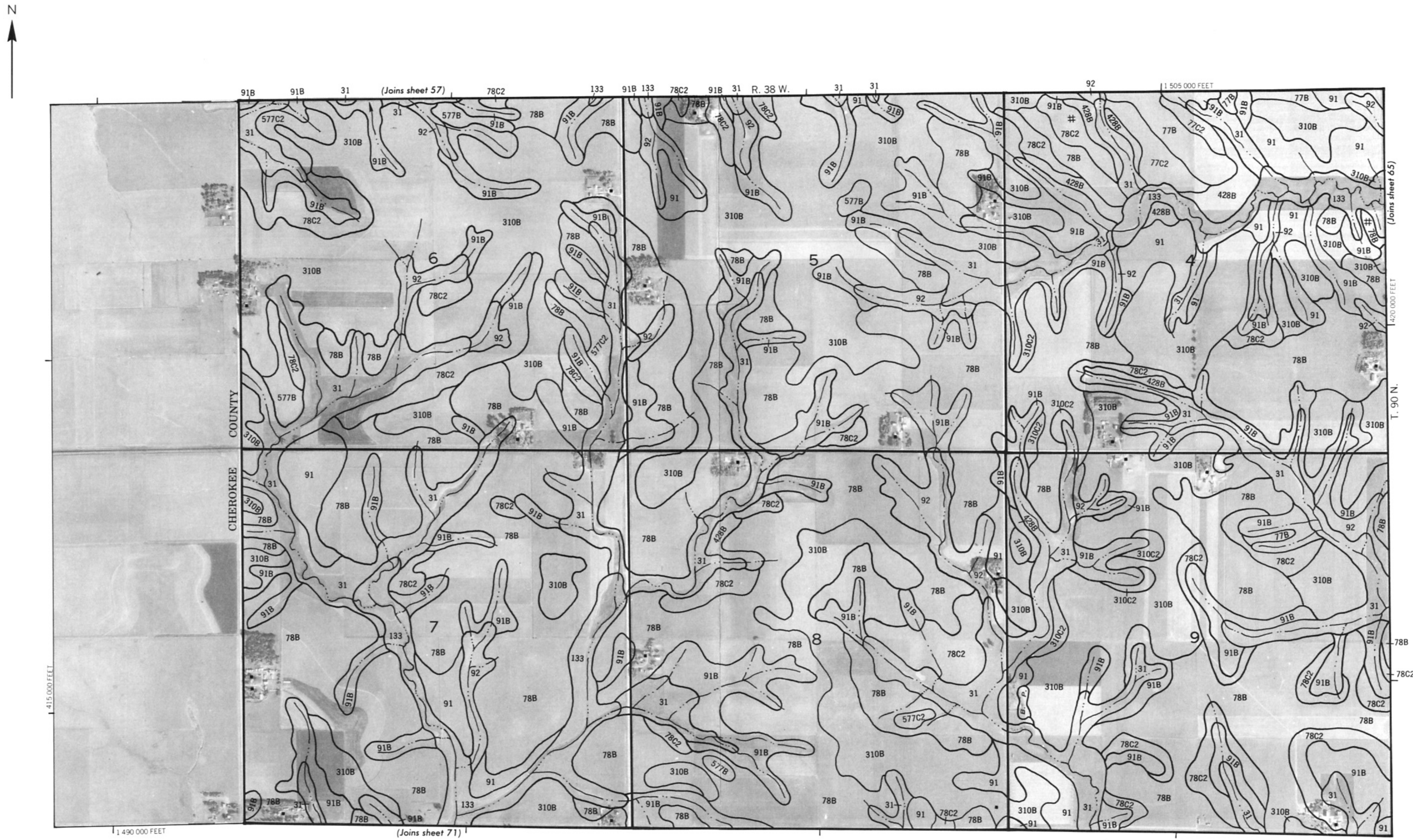

N
R. 36 W.
T. 91 N.
1 565 000 FEET
1 580 000 FEET
430 000 FEET
425 000 FEET
(Joins sheet 54)
(Joins sheet 60)
(Joins sheet 62)
(Joins sheet 68)
NORTH
RACCOON
RIVER
29
28
27
26
32
33
34
35

N

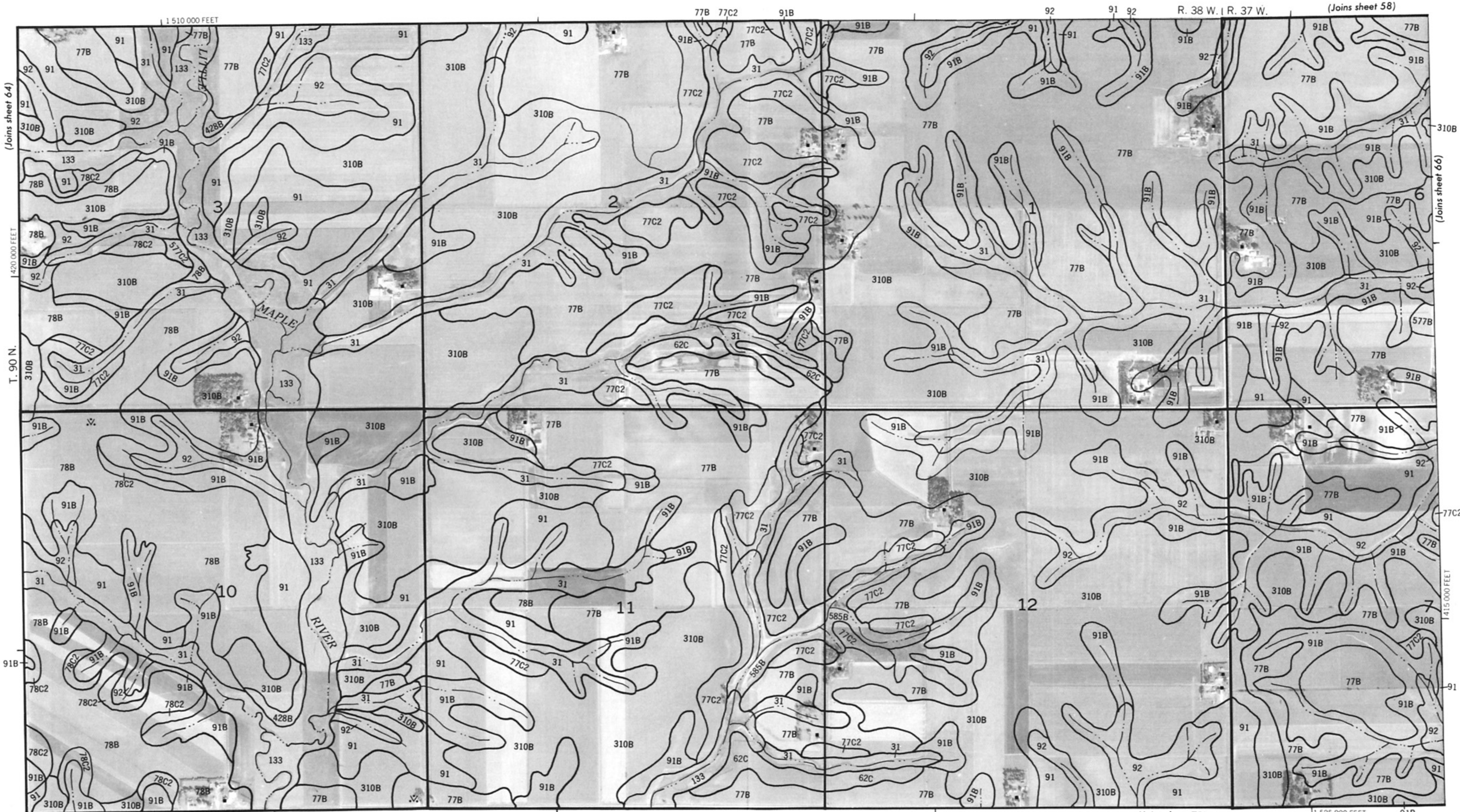

(Joins sheet 55)
R. 36 W. | R. 35 W.
1 600 000 FEET
(Joins sheet 63)
430 000 FEET
T. 91 N.
(Joins sheet 61)
425 000 FEET
NORTH
RACCOON
RIVER
Drainage Ditch
101
1 585 000 FEET
(Joins sheet 69)
25
30
31
32
36
31
32
33


N
R. 35 W.
1 605 000 FEET
(Joins sheet 56)
430 000 FEET
(Joins sheet 62)
T. 91 N.
POCAHONTAS COUNTY
425 000 FEET
1 615 000 FEET
(Joins sheet 70)
28
27
26
25
33
34
35
36

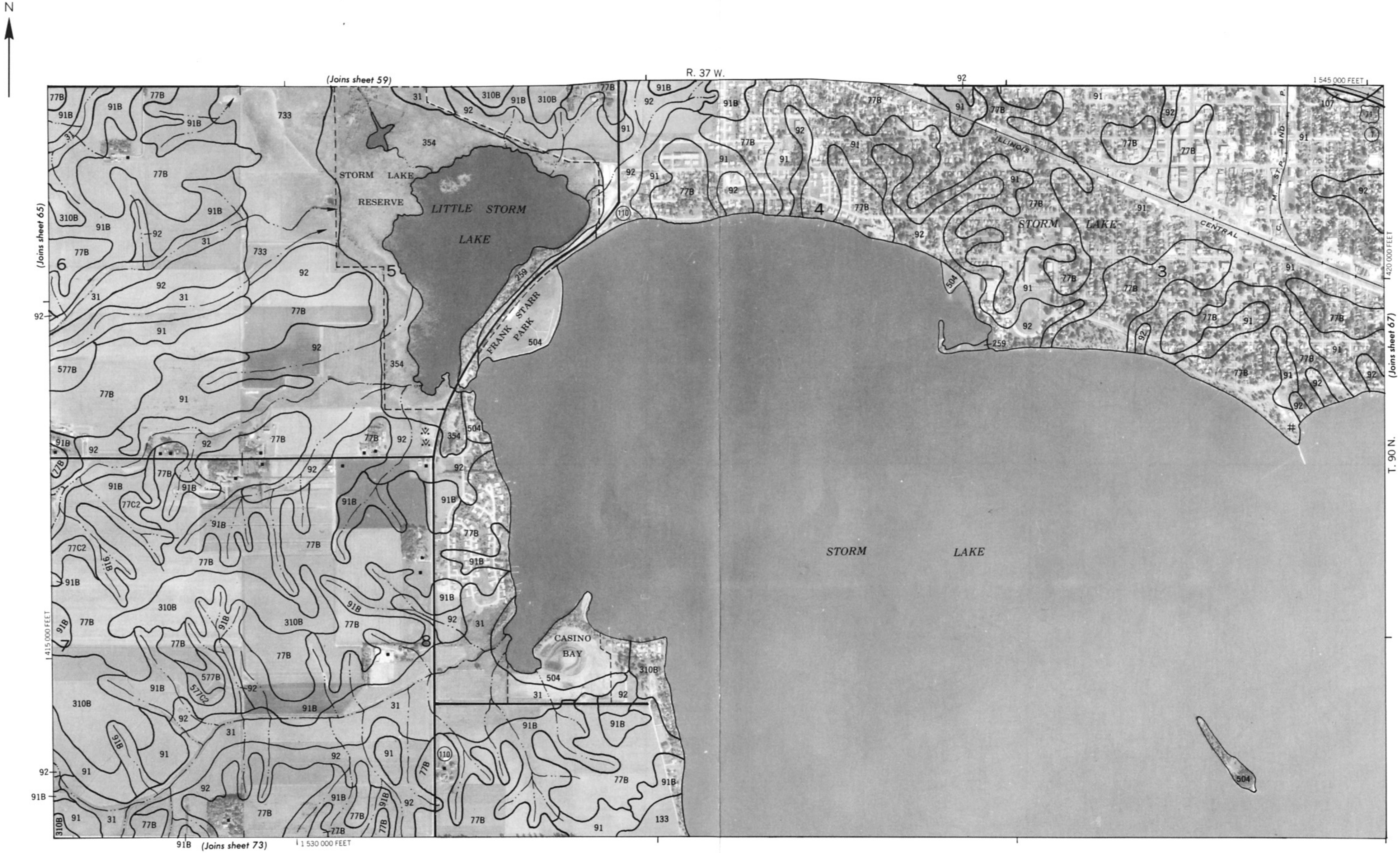
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 64



N


1 510 000 FEET
R. 38 W.
R. 37 W.
(Joins sheet 58)
(Joins sheet 64)
(Joins sheet 66)
(Joins sheet 72)
420 000 FEET
415 000 FEET
1 525 000 FEET
T. 90 N.
LITTLE
MAPLE
RIVER
1
2
3
6
7
10
11
12

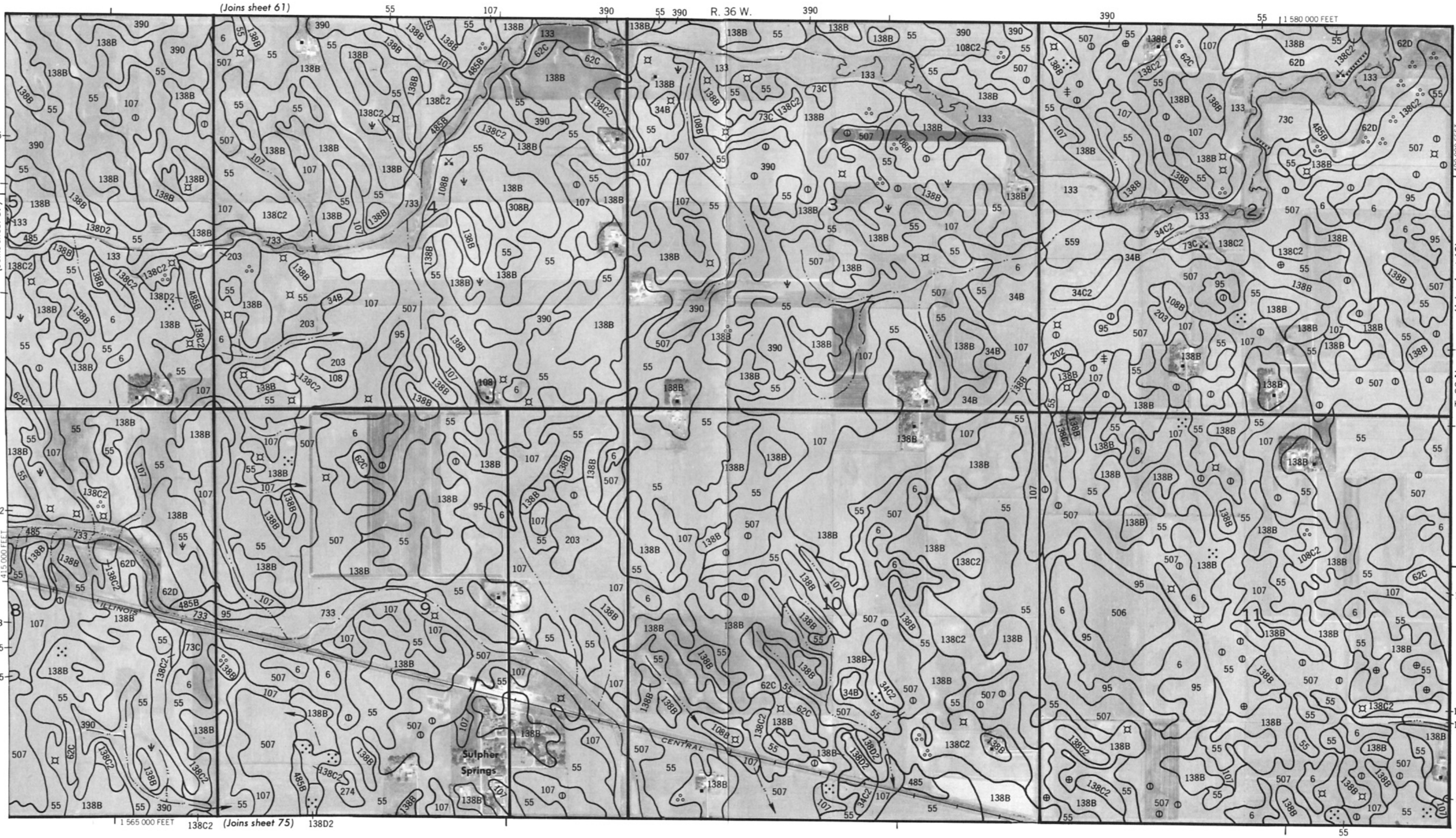
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 66

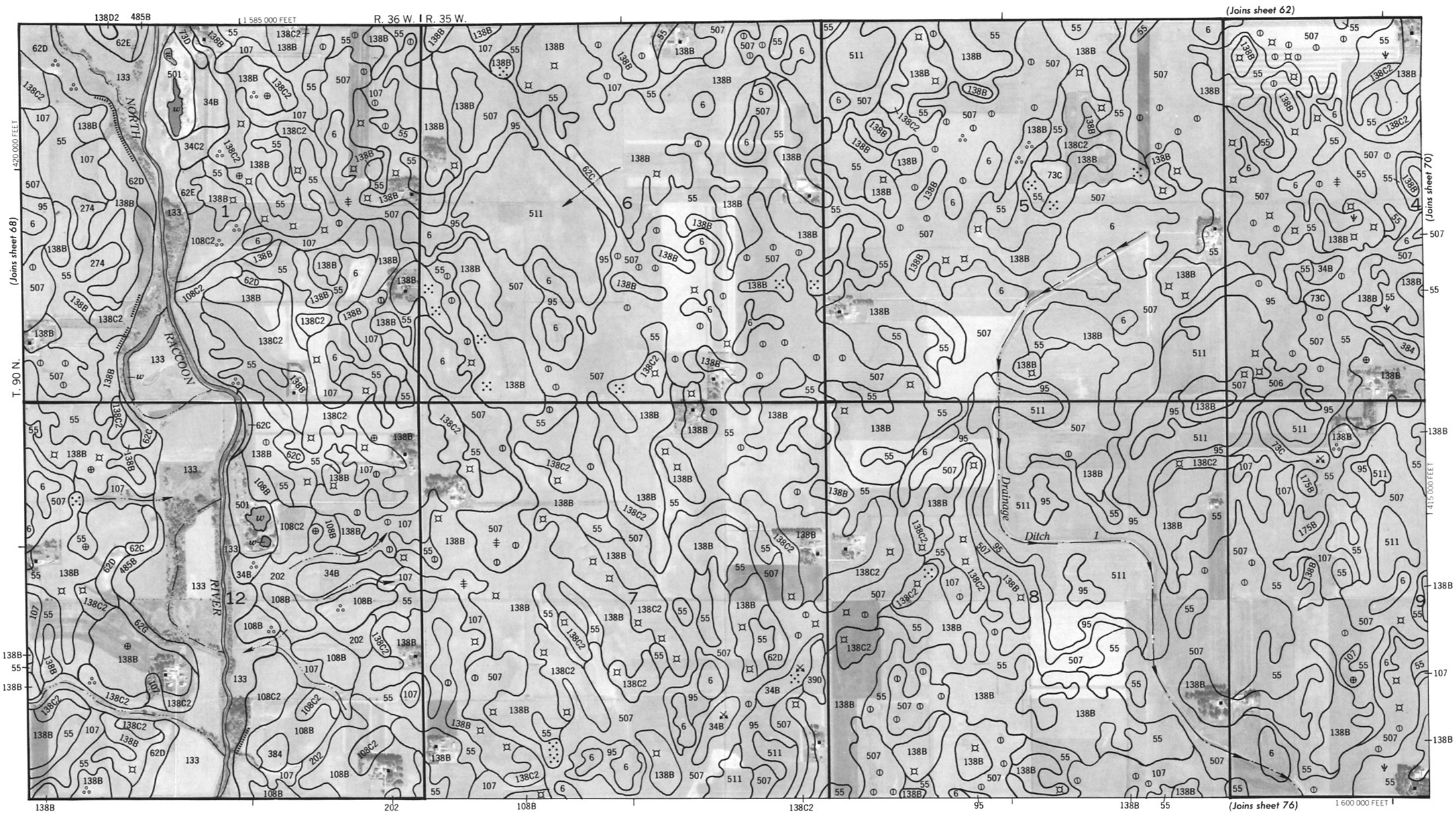



N
1 550 000 FEET
R. 37 W. | R. 36 W.
(Joins sheet 60)
420 000 FEET
T. 90 N.
STORM LAKE
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
ILLINOIS
CENTRAL
STORM LAKE
LAKESIDE
415 000 FEET
1 560 000 FEET
(Joins sheet 74)

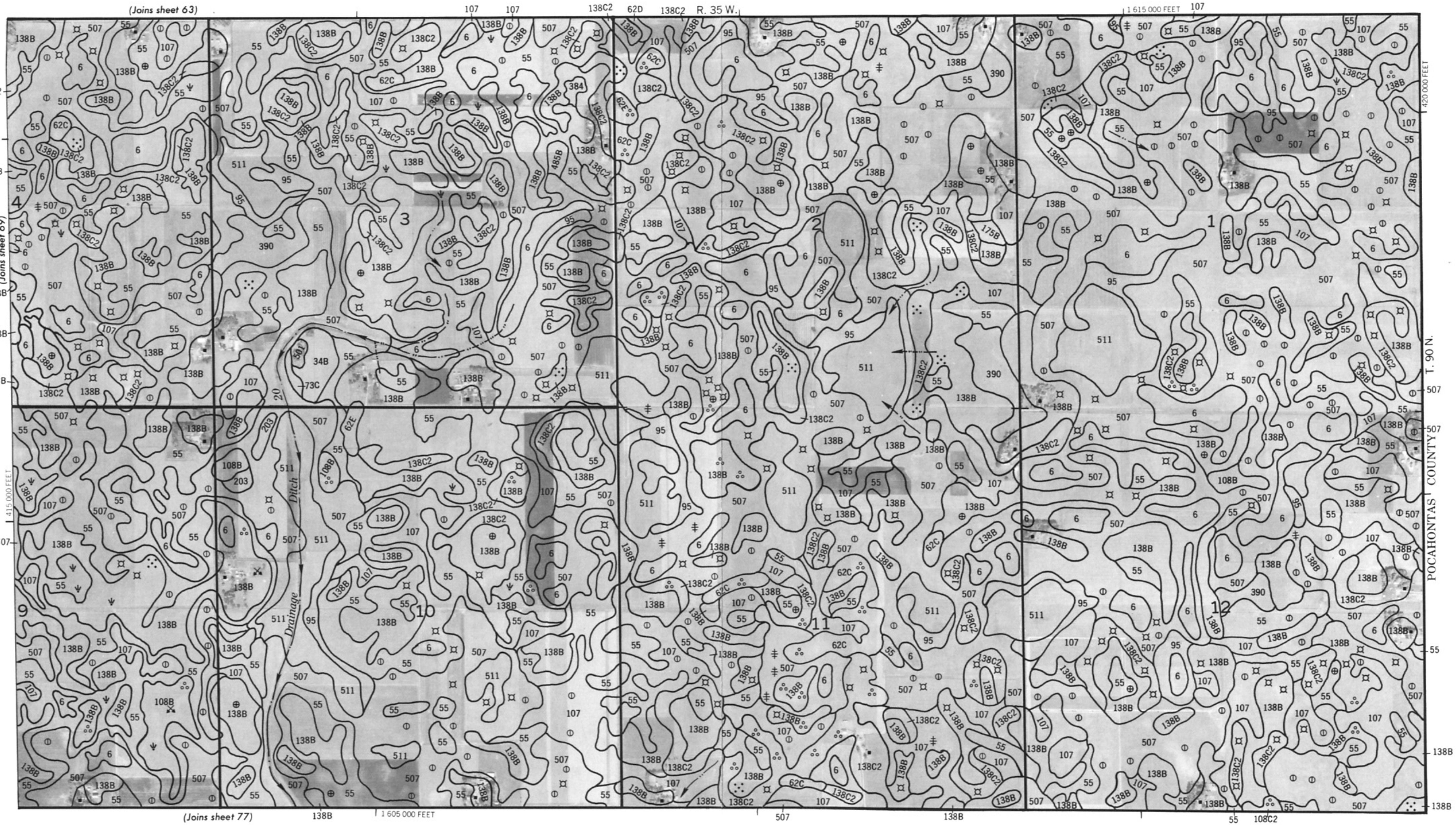
BUENA VISTA COUNTY, IOWA — SHEET NUMBER 68

N

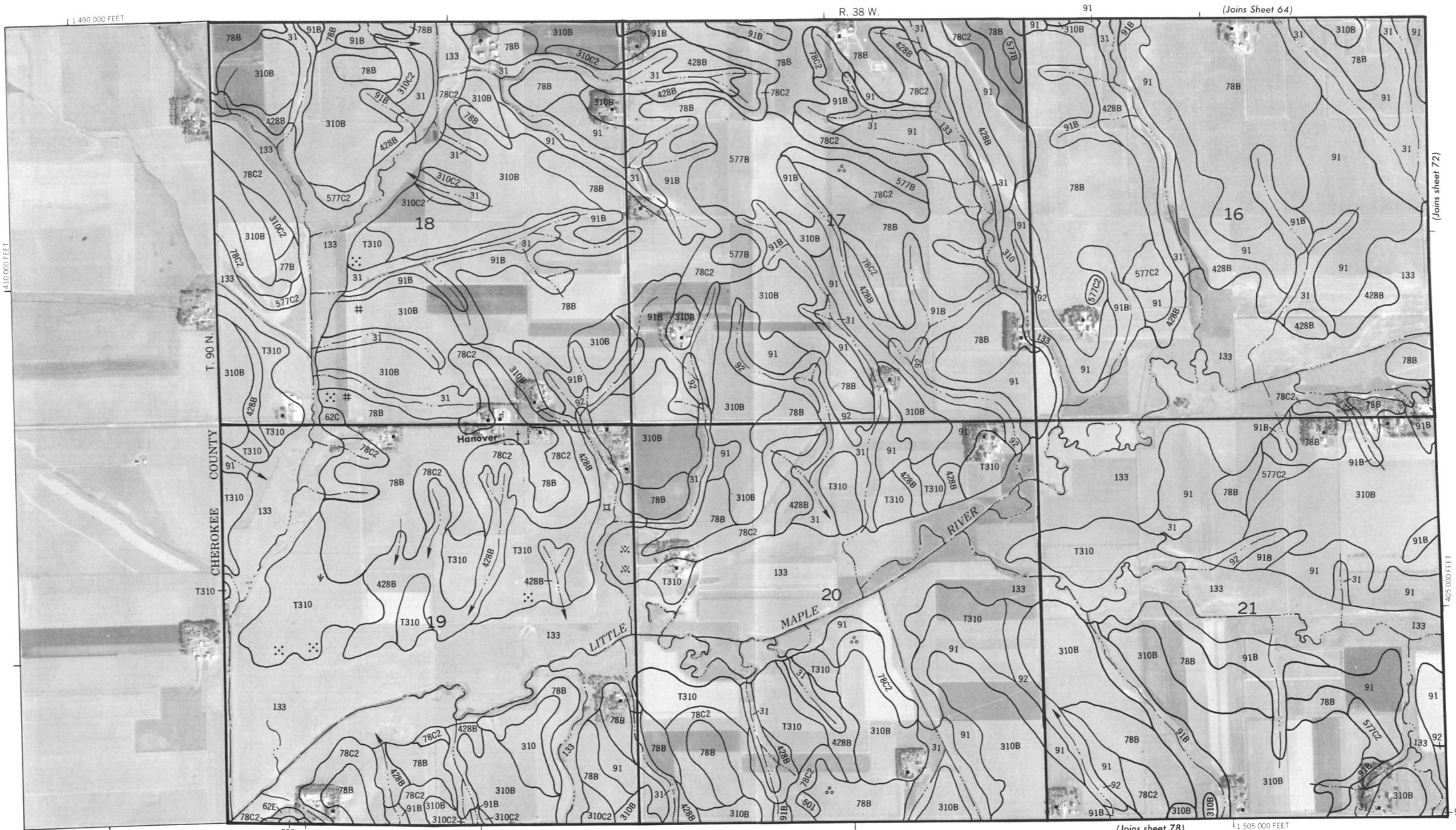



N
(Joins sheet 62)
(Joins sheet 68)
(Joins sheet 70)
(Joins sheet 76)
R. 36 W. | R. 35 W.
T. 90 N.
1 585 000 FEET
1 600 000 FEET
420 000 FEET
1 415 000 FEET
NORTH RACCOON RIVER
Drainage Ditch 1
1
4
5
6
7
8
9
12

N


(Joins sheet 63)
(Joins sheet 69)
(Joins sheet 77)
R. 35 W.
T. 90 N.
POCAHONTAS COUNTY
1 615 000 FEET
1 605 000 FEET
420 000 FEET
415 000 FEET
Drainage Ditch
20
1
2
3
4
6
9
10
11
12

N

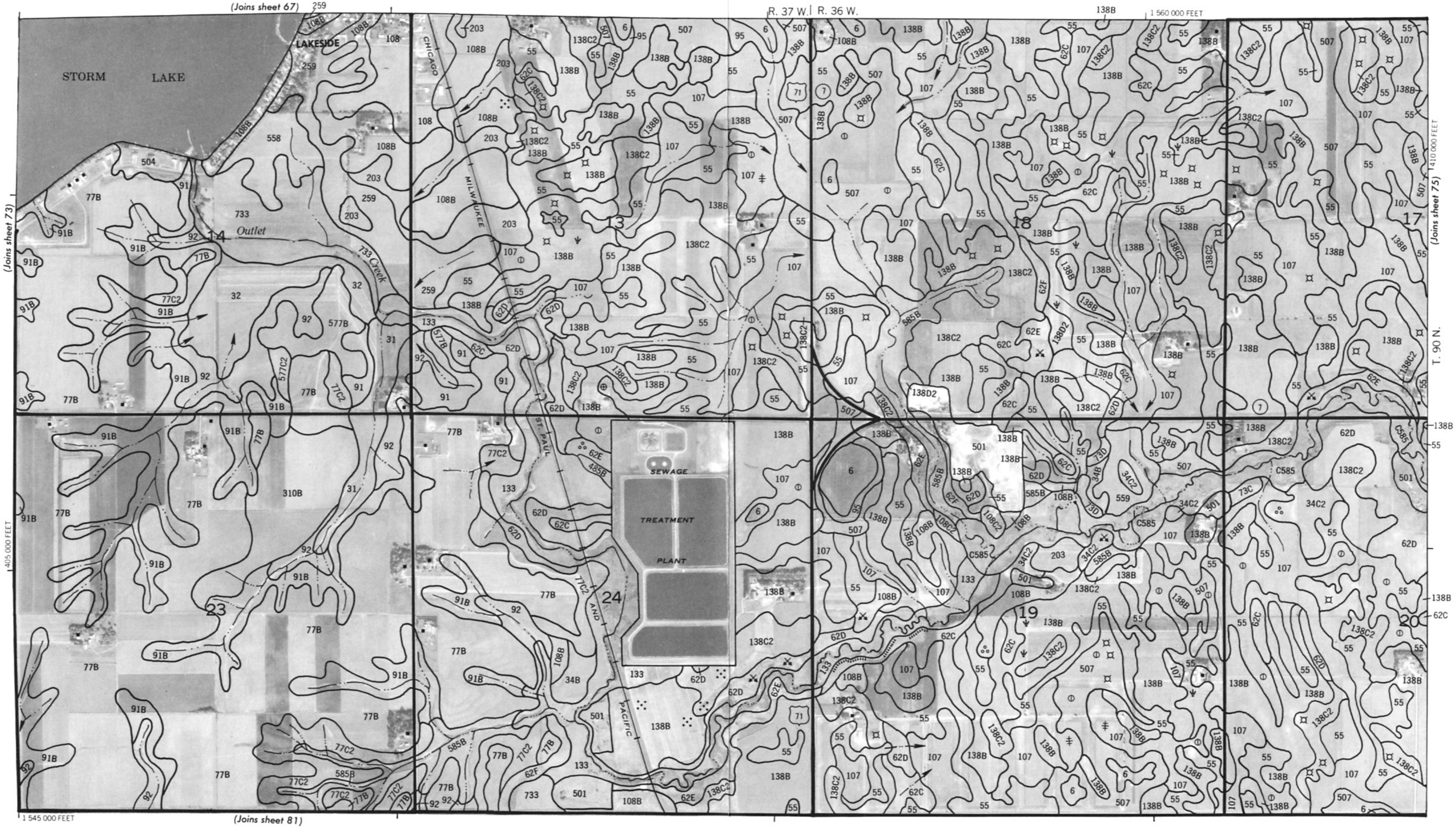

1 490 000 FEET
R. 38 W.
(Joins Sheet 64)
(Joins sheet 72)
(Joins sheet 78)
410 000 FEET
405 000 FEET
1 505 000 FEET
T. 90 N.
CHEROKEE COUNTY
Hanover
LITTLE MAPLE RIVER
18
17
16
19
20
21

N

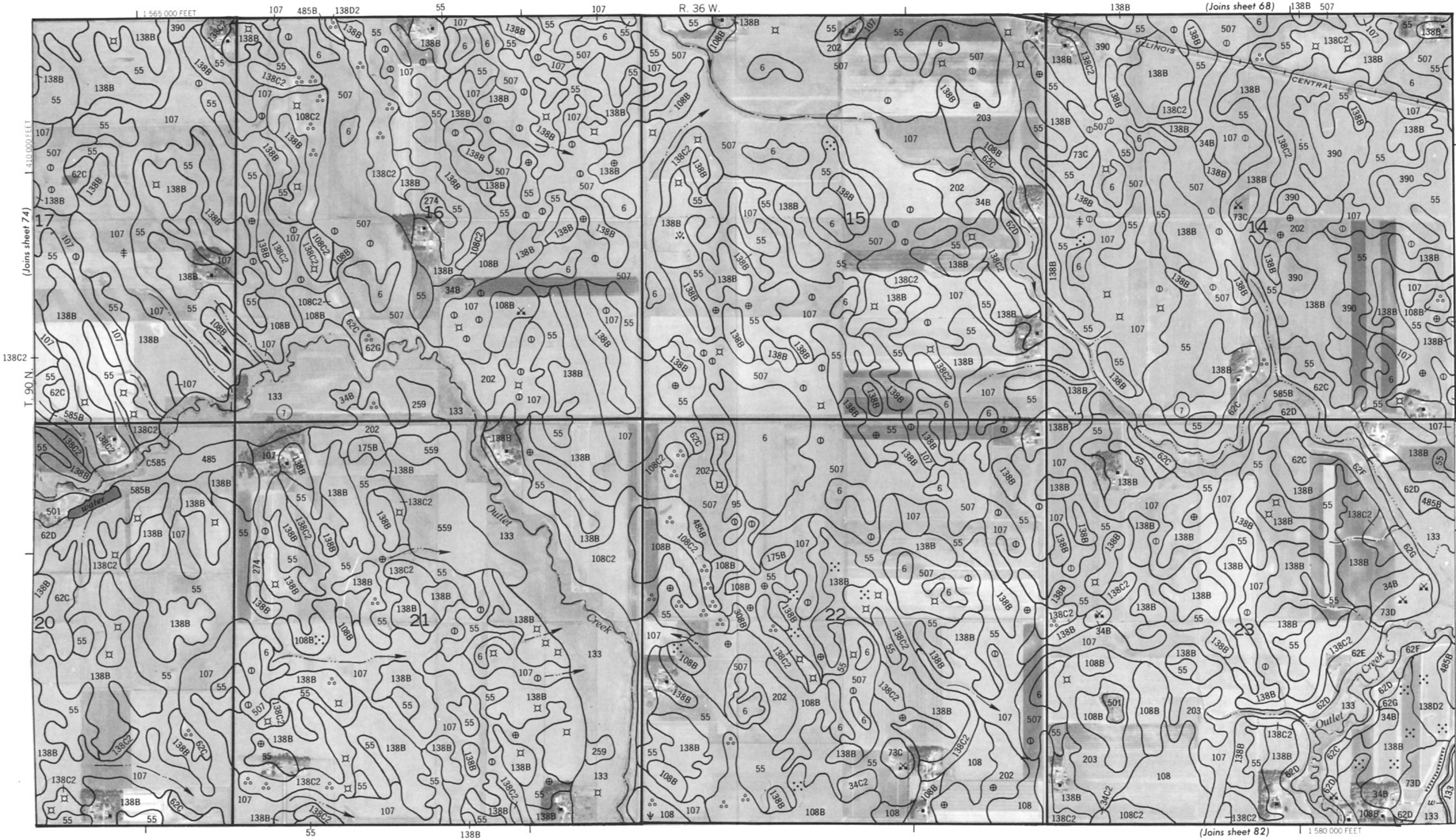

(Joins sheet 65)
(Joins sheet 71)
(Joins sheet 73)
(Joins sheet 79)
R. 38 W. | R. 37 W.
T. 90 N.
1 525 000 FEET
410 000 FEET
405 000 FEET
1 510 000 FEET
LITTLE
MAPLE
RIVER
BOYER
RIVER
15
14
13
18
22
23
24
19

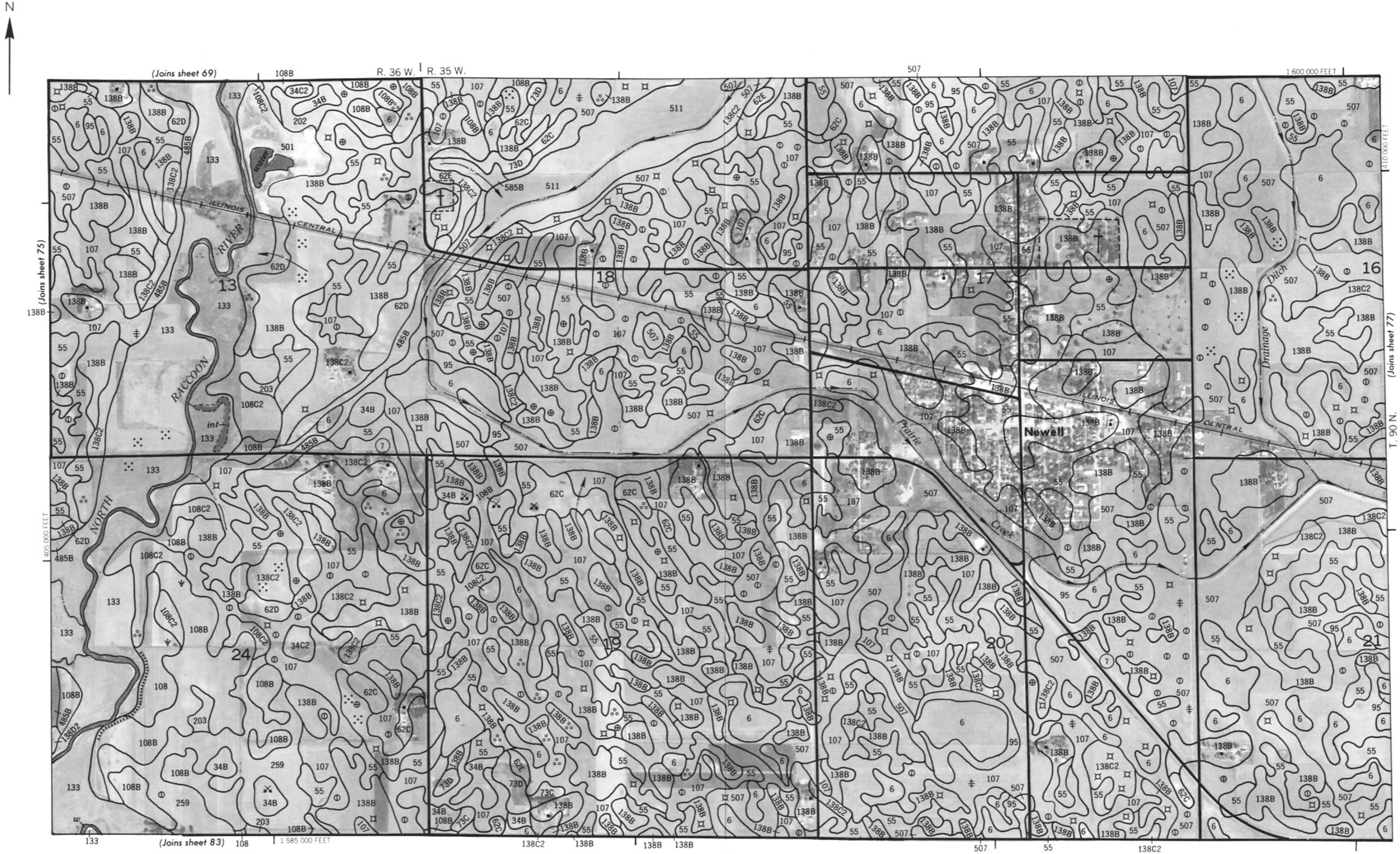

N
R. 37 W.
(Joins sheet 66)
(Joins sheet 72)
(Joins Sheet 74)
(Joins sheet 80)
T. 90 N.
1 530 000 FEET
1 545 000 FEET
410 000 FEET
405 000 FEET
STORM LAKE
STORM LAKE AIRPORT
Boyer Creek
15
16
17
18
19
20
21
22

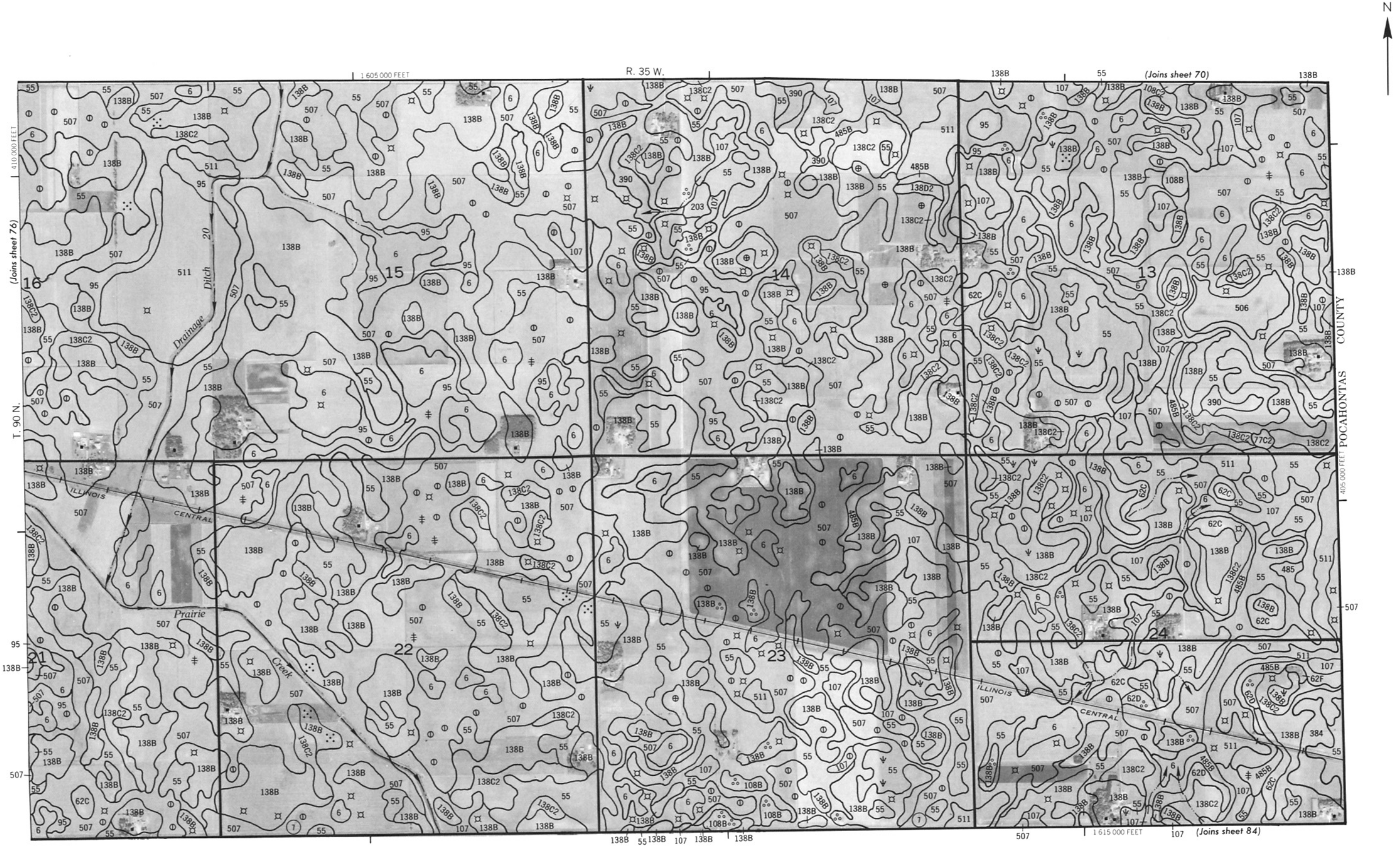
N


(Joins sheet 67)
STORM LAKE
LAKESIDE
R. 37 W.
R. 36 W.
1 560 000 FEET
(Joins sheet 73)
(Joins sheet 75)
T. 90 N.
410 000 FEET
405 000 FEET
Outlet
Creek
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
SEWAGE
TREATMENT
PLANT
1 545 000 FEET
(Joins sheet 81)

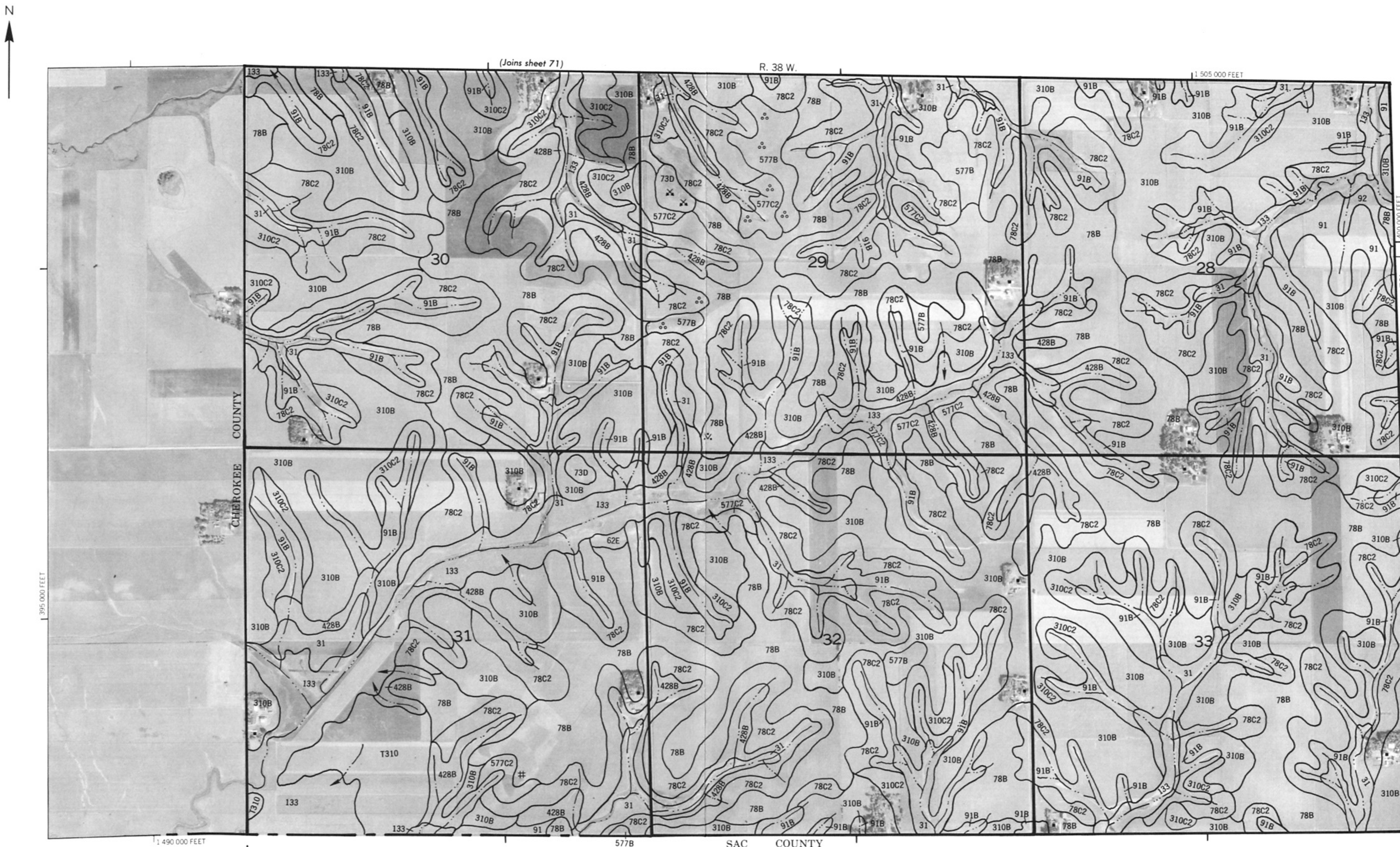
N

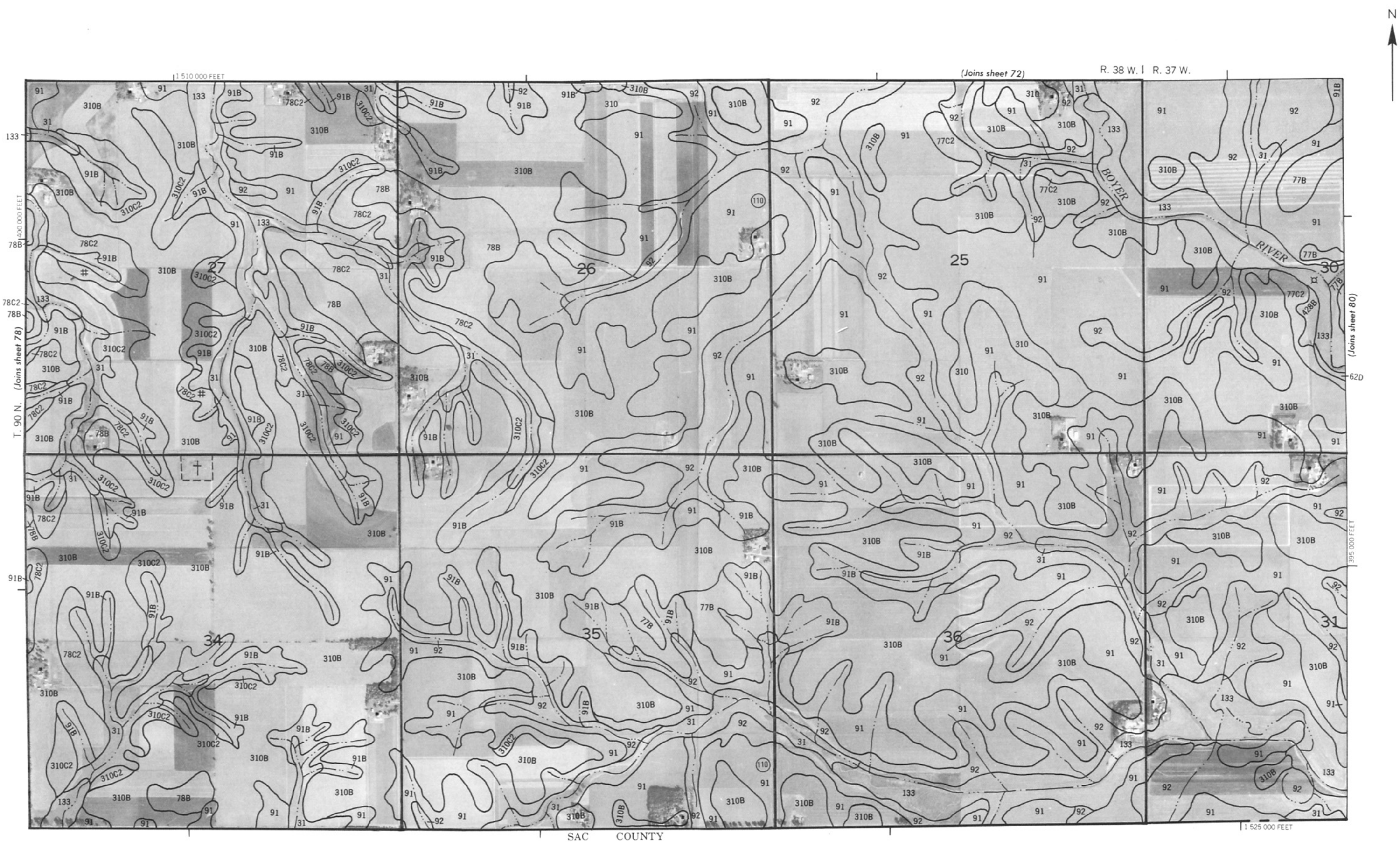

1 565 000 FEET
R. 36 W.
(Joins sheet 68)
(Joins sheet 74)
(Joins sheet 76)
(Joins sheet 82)
410 000 FEET
405 000 FEET
1 580 000 FEET
T. 90 N.
ILLINOIS CENTRAL
Outlet Creek
water
17
16
15
14
20
21
22
23

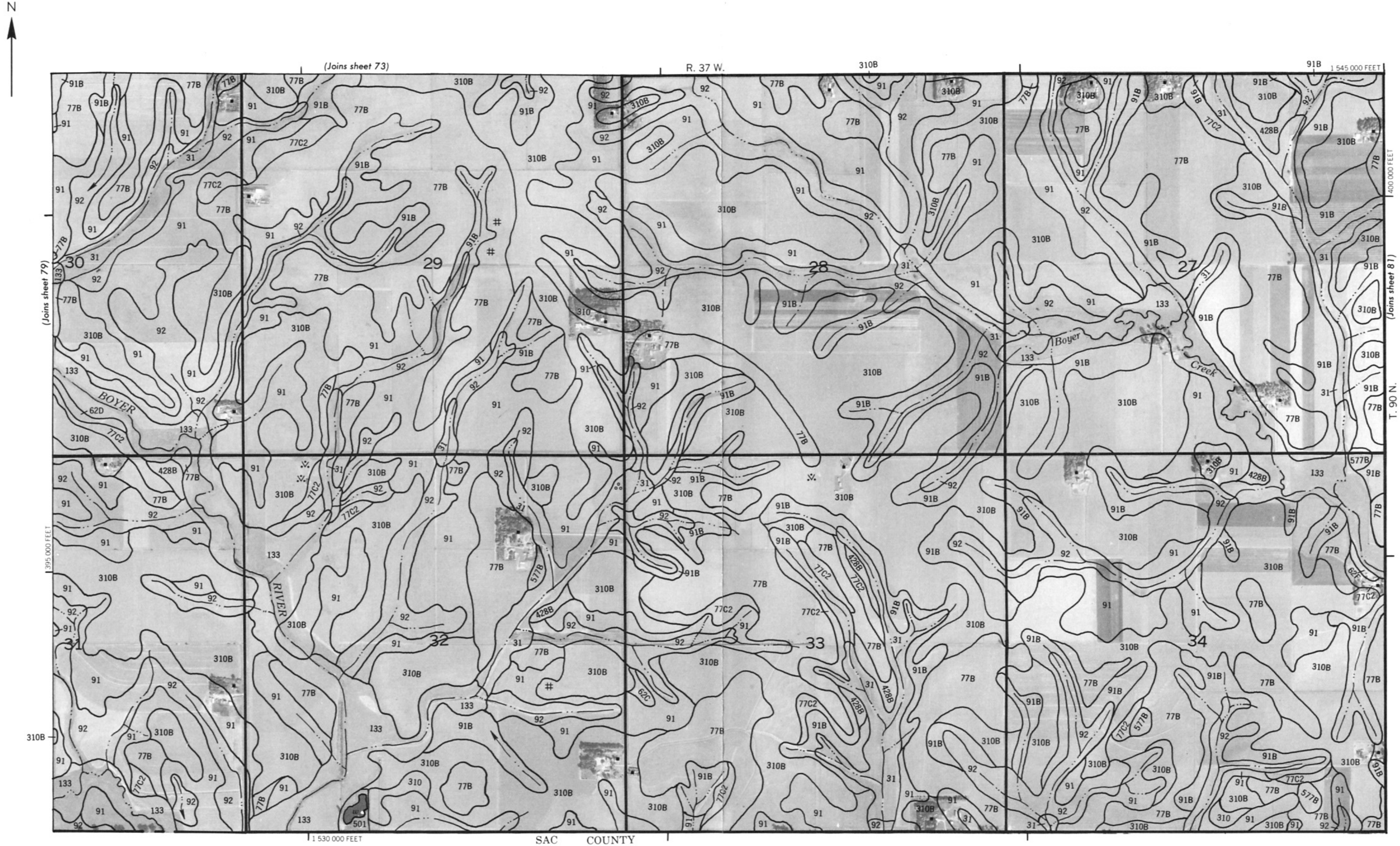

N
(Joins sheet 69)
R. 36 W.
R. 35 W.
1 600 000 FEET
410 000 FEET
(Joins sheet 75)
(Joins sheet 77)
T. 90 N.
405 000 FEET
(Joins sheet 83)
1 585 000 FEET
ILLINOIS CENTRAL
RACCOON RIVER
NORTH
Prairie Creek
Drainage Ditch
Newell
water
13
18
17
16
24
19
20
21


N
R. 35 W.
1 605 000 FEET
1 615 000 FEET
410 000 FEET
405 000 FEET
(Joins sheet 70)
(Joins sheet 76)
(Joins sheet 84)
T. 90 N.
POCAHONTAS COUNTY
Drainage Ditch 20
Prairie Creek
ILLINOIS CENTRAL
16
15
14
13
21
22
23
24

BUENA VISTA COUNTY, IOWA — SHEET NUMBER 78

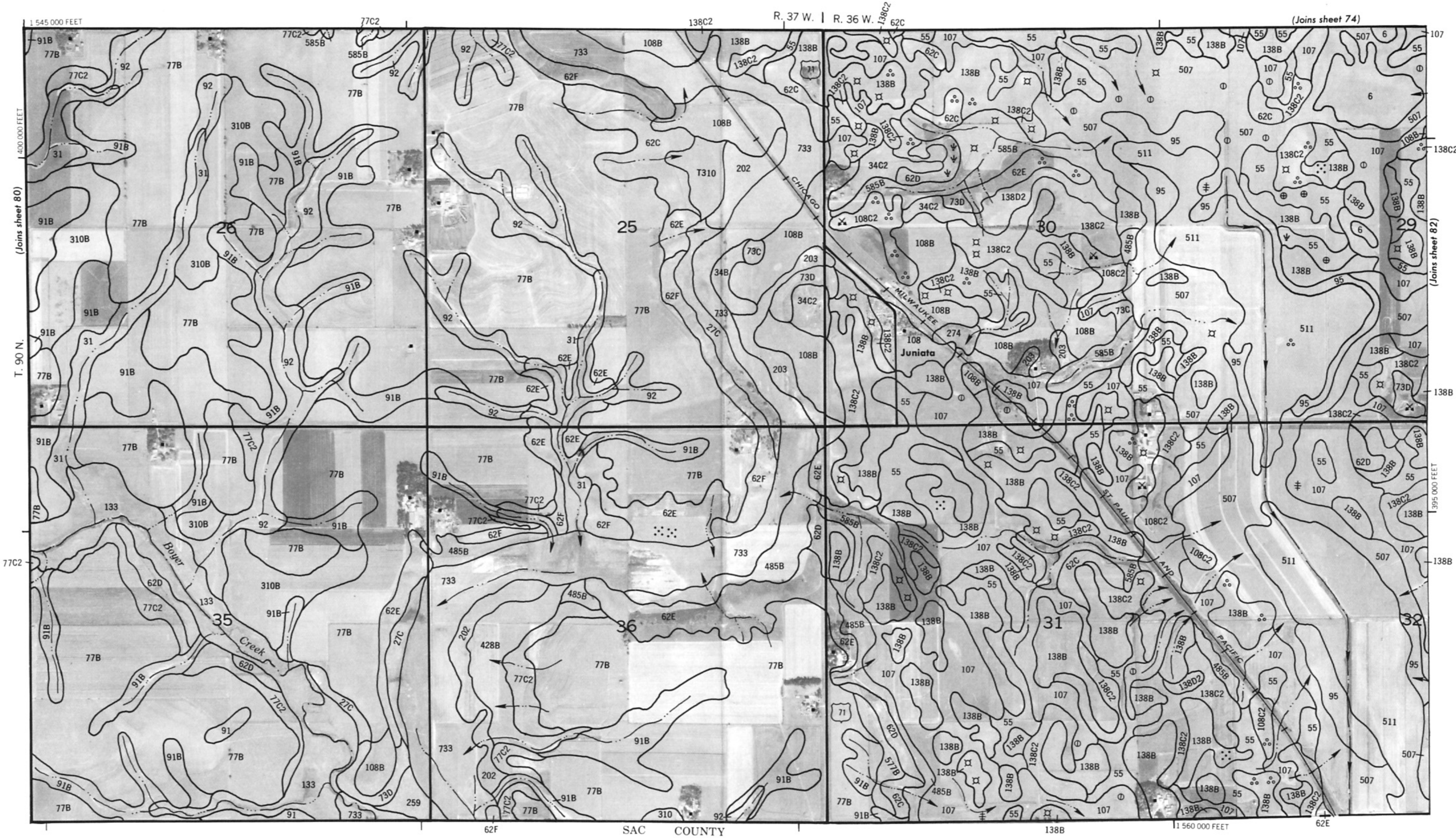


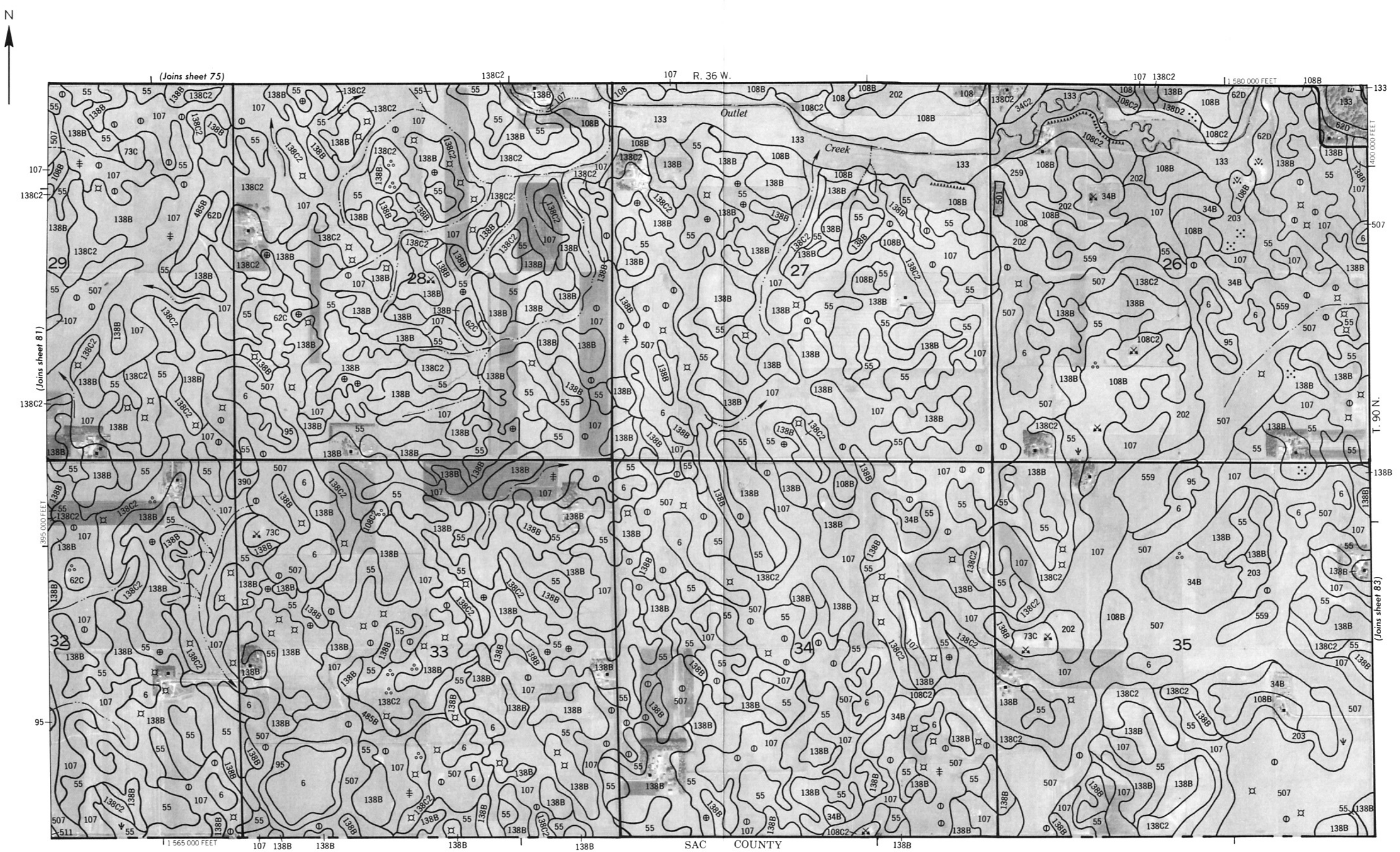

N
1 510 000 FEET
(Joins sheet 72)
R. 38 W.
R. 37 W.
400 000 FEET
395 000 FEET
1 525 000 FEET
(Joins sheet 78)
(Joins sheet 80)
T. 90 N.
BOYER
RIVER
27
26
25
30
34
35
36
31
SAC COUNTY


N
(Joins sheet 73)
R. 37 W.
1 545 000 FEET
400 000 FEET
(Joins sheet 79)
(Joins sheet 81)
T. 90 N.
395 000 FEET
1 530 000 FEET
SAC COUNTY
30
29
28
27
31
32
33
34
BOYER
RIVER
Boyer
Creek

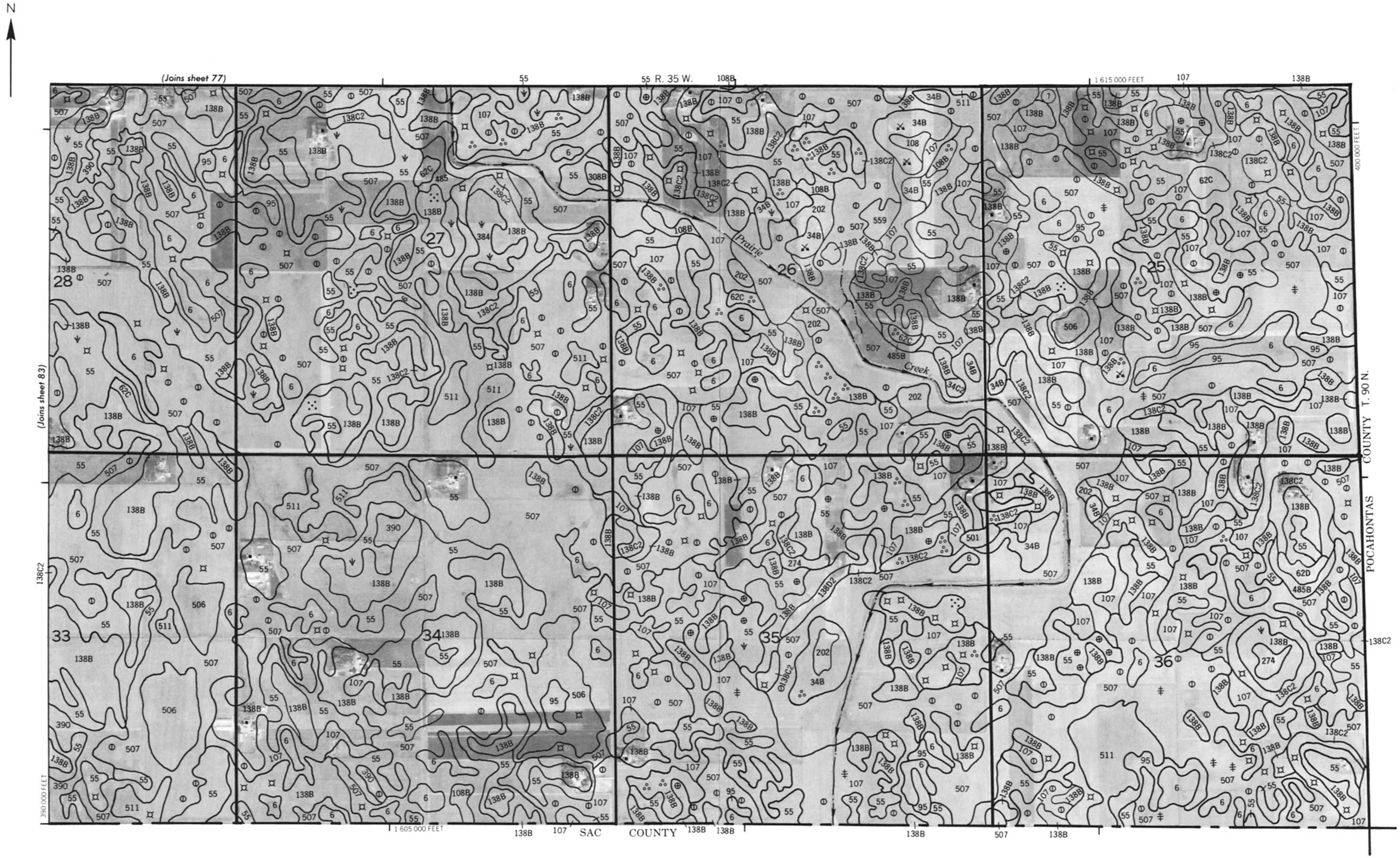
81

N


1 545 000 FEET
R. 37 W.
R. 36 W.
(Joins sheet 74)
(Joins sheet 80)
(Joins sheet 82)
400 000 FEET
395 000 FEET
1 560 000 FEET
T. 90 N.
26
25
30
29
35
36
31
32
Juniata
CHICAGO
MILWAUKEE
ST. PAUL
AND
PACIFIC
Boyer
Creek
71
SAC
COUNTY


N
(Joins sheet 75)
R. 36 W.
1 580 000 FEET
400 000 FEET
(Joins sheet 81)
(Joins sheet 83)
T. 90 N.
395 000 FEET
1 565 000 FEET
Outlet
Creek
SAC COUNTY
29
28
27
26
32
33
34
35


N
R. 36 W.
R. 35 W.
1 585 000 FEET
400 000 FEET
(Joins sheet 76)
(Joins sheet 82)
(Joins sheet 84)
T. 90 N.
NORTH
RACCOON
RIVER
PLEASANT LAKE
25
30
29
28
36
31
32
33
SAC COUNTY
390 000 FEET
1 600 000 FEET


N
(Joins sheet 77)
R. 35 W.
1 615 000 FEET
400 000 FEET
(Joins sheet 83)
390 000 FEET
1 605 000 FEET
T. 90 N.
POCAHONTAS COUNTY
SAC COUNTY
Prairie
Creek
25
26
27
28
33
34
35
36